LIBRARY
OHIO NORTHERN UNIVERSITY

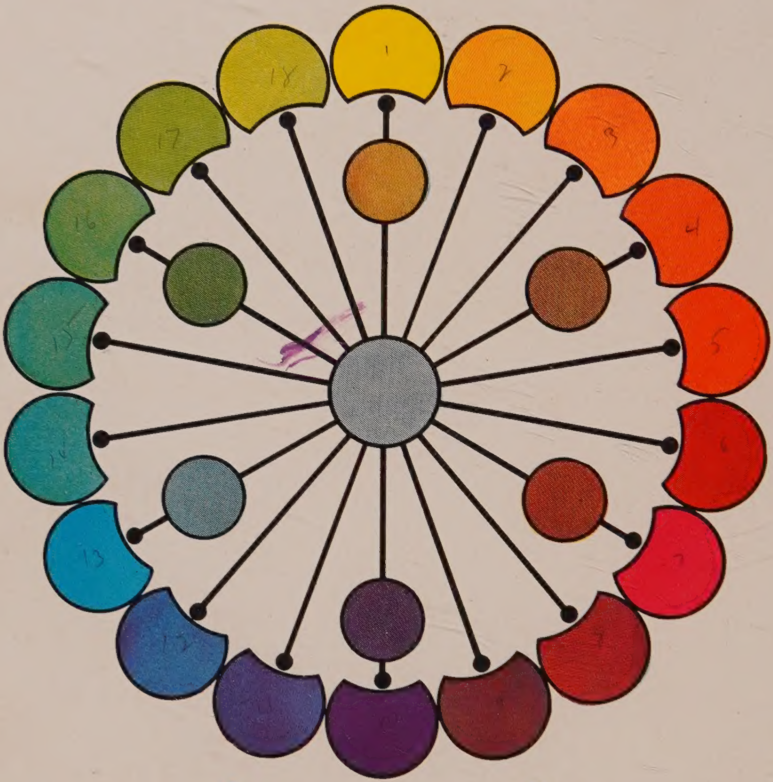
REGULATIONS

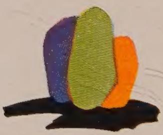
1. Books may be borrowed for a period of two weeks.
2. At the expiration of two weeks books may be re-let if returned to the librarian in good condition.
3. A rental of two cents a day will be charged on each book held over two weeks.

Class No. 698.3 Accession No. 21024

Memorial Library

1.9c.d





An eighteen-step color circle, made from the three primary colors, the secondary colors, and two intermediate hues. At the center is neutral gray. The six small circles represent primary and secondary colors which have been somewhat grayed with complementary colors.

The color circle was furnished through the courtesy of Professor Clayton H. Staples of the Art Department of the Illinois State Normal University.

COLORING, FINISHING AND PAINTING WOOD

By

ADNAH CLIFTON NEWELL

PROFESSOR OF INDUSTRIAL ARTS
ILLINOIS STATE NORMAL UNIVERSITY

Author of *Wood and Lumber*

OHIO NORTHERN UNIVERSITY
LIBRARY
ADA, OHIO

THE MANUAL ARTS PRESS
PEORIA, ILLINOIS

COPYRIGHT, 1930
ADNAH CLIFTON NEWELL

Printed in the United States of America

698.3
N54c
1930

PREFACE

UNSATISFACTORY results in wood-finishing are almost universal in the one-room industrial-arts departments of public schools. Not until it becomes generally known that wood-finishing is a highly-developed trade in itself, and that a teacher needs much technical knowledge and some experience to teach it well, will conditions be much improved. This deficiency in teacher training has been recognized by several of the most progressive universities and teachers colleges, and separate courses in the theory and practice of wood-finishing are now being offered. This book is especially prepared for this field, and contains a rich background of related scientific information in order to furnish educative elements that should accompany the purely manipulative processes that are learned in acquiring the art of wood-finishing and painting.

One function of this book is to give interesting and valuable information about the new and widely-used wood-finishes and painting materials which have very recently appeared on the market.

The marvelous progress in technical knowledge and the discoveries of scientists, especially chemists, have practically revolutionized many of our present-day industries, and modified or greatly changed some of the well-established arts that have been known and used for ages. In the field of color, chemical wizards have struck a rock that we call coal-tar, and just as Moses at Meribah "smote the rock twice: and the water came out abundantly," so have the modern alchemists broken up the molecules of coal-tar, and out from a black mass without beauty have come all the tints, colors, and nuances of the rainbow. These recent discoveries have changed the kinds of stains and dyes used by the wood-finisher and the dyer of cloth from the so-called permanent vegetable dyes to coal-tar dyes which are now

21024

cheap and reliable. The result of these changes is evident because most of the formulas of just a few years ago for mixing stains for wood are out of date and are not now used in industry.

Present-day colors, and the new methods of coloring or staining wood now used in industry, have been described in this book with painstaking care in order to meet the rapidly-growing demand of technical students in schools, women in the home, lovers of arts and crafts, architects, and professional wood-finishers and painters for reliable information about dyes and pigments that will help in making the home beautiful.

Another phase of the book of interest to people of a scientific turn of mind will be found in the discussions of the new types of varnish which have appeared on the market recently, partly as a result of the discovery of new methods of treating and preparing a Chinese drying-oil called tung-oil in such a manner that it has become usable and very valuable as a vehicle for varnishes, and partly because of the development or invention of new, useful, synthetic gums which have taken the place of many of the highly-prized, hard fossil gums which are becoming very scarce and expensive. These new gums have changed the character and composition of our present-day varnishes. Surely the modern varnish-maker's kettle is the witches' caldron of today. Into a kettle of gigantic size our conjurer throws a common, very cheap rosin which is changed by heat and the chemist's magic—in the form of glycerine—and out comes a new material, known as ester gum, which can be used in manufacturing excellent varnishes.

An additional change in the art of wood-finishing has come about thru the rapid progress in the development of quick-drying, very permanent, nitrocellulose lacquers which are new finishes derived from the realm of magic and mystery. Much new and useful information about brushing and spraying lacquers and their uses will be found in two chapters of this book. Present-day lacquers contain varnish-gums in addition to nitrocellulose, and dry so quickly that they are practically dust-proof; yet they set slowly enough so that they can be applied with little training by use of either a brush or a spray-gun. The student wood-finisher in the school, the arts and crafts painter in the home who wishes to refinish old furniture or woodwork, and the professional painter will all find new and helpful hints and much practical information about lacquer and its use in this volume.

While it is true that the emphasis has been placed on new materials and processes, mention should be made of the fact that the entire field of wood-finishing, including wood-filling, shellacking, and enameling, has been comprehensively treated in the various chapters.

As a part of the research work in the preparation of this book, many microscopic studies were made of the reaction of various finishes, especially wood-fillers, in the pores of several kinds of wood. Many technical difficulties were encountered in attempts to prepare photomicrographs of wood-filler in the pores of wood, nevertheless some interesting information was secured.

Some new and very valuable paint-pigments, such as lithophone, titanox, and "extenders," such as asbestine, have appeared recently and are now used rather extensively in the paint trade. For many purposes these new materials can be used to advantage. The person who applies paint at the present time has a wide field to choose from in selecting pigments, extenders, colors, drying-oils, and thinners, and needs information about these materials.

Another very fundamental characteristic of this volume is that wood-finishing is treated as a science as well as an art. It is for this reason that a rich background of related science is given in connection with the descriptions of the materials and the methods of using them. The chemical formulas of the substances described are usually given, and some of the chemical and physical reactions of the materials are pointed out for the benefit of the amateur, the apprentice, or the master painter who may lack a thoro scientific background for his trade. The related science in this book has been gathered with meticulous care thru visits to some of the best paint, varnish, and lacquer factories in the United States in order to obtain up-to-date, reliable information. A very careful study has also been made of the writings of scientists, and valuable reference sheets have been placed at the end of each chapter.

In the industrial-arts departments of schools, wood-finishing and painting have often been taught in connection with woodworking, but at present there is a strong tendency toward the establishment of separate courses in which the informational aspect of wood-finishing and painting can receive proper attention.

The industrial-arts departments of 30 years ago gave little attention to wood-finishing, and attempts were made to finish articles in dusty woodworking shops; now separate rooms, after the universal practice of industry, will be found in all schools where serious work in wood-finishing is done.

The science and art of wood-finishing can be more clearly understood thru a study of wood as a material. The publishers of this book have prepared another volume—*"Wood and Lumber"*—which can be used to advantage in schools when related information and a scientific background are desired in order to give a more intellectual trend to shopwork which may be too largely manual or manipulative to be educational and vocational in the best sense.

It would be difficult to name all the people who have given generous and valuable help in the preparation of this book. The officers of the Sherwin-Williams Company, of Chicago, deserve commendation and thanks for illustrations which appear in several places in the book, and for making available important scientific information. The chief research work was done at the library of the Illinois State Normal University where the librarians rendered much helpful assistance. The John Crerar Library of Chicago, and the library of the Department of Chemistry of the University of Illinois, also rendered valuable aid. Mention should also be made of the assistance of Mr. Ralph Weber in preparing the drawings and illustrations. Professor Clayton H. Staples, head of the Art Department at Illinois State Normal University, prepared the 18-step color-circle which is used as a frontispiece.

A. C. NEWELL.

Normal, Illinois
July 4, 1929

CONTENTS

Page

PREFACE 3

CHAPTER I. PREPARATION OF THE SURFACE OF WOOD WITH PLANE AND SCRAPER 15

1. Wood must be dry. 2. Use great care in preparing the surface. 3. Planing the surface by hand. 4. Scrapers and their use. 5. Plugs and cement for holes and cracks.

CHAPTER II. SURFACE ABRASIVES AND THEIR USE . . . 26

6. Inspection before sandpapering. 7. Sandpaper manufacture. 8. Sizes of sandpaper. 9. Use of sandpaper. 10. Steel wool and its use. 11. Sponging and resanding. 12. Dust sanded surfaces.

CHAPTER III. WOOD-STAINS AND WATER-STAINING . . 37

Wood-stains: 13. Reasons for staining. 14. Definition of wood-staining. 15. Classification of wood-stains. 16. Water-stains. 17. Advantages of water-stains. 18. Disadvantages of water-stains. 19. Helpful hints on water-staining.

CHAPTER IV. OIL-STAINS 50

20. Three kinds of stain. 21. Pigment oil-stains. 22. Preparation of pigment oil-stains. 23. Advantages of pigment oil-stains. 24. Disadvantages of pigment oil-stains. 25. Use of pigment oil-stains. 26. Creosote oil-stains. 27. Volatile oil-stains. 28. Permanency of oil-soluble coal-tar stains. 29. Shellac-wash over volatile oil-stains.

CHAPTER V. SPIRIT-STAINS AND APPLYING STAINS . . 59

Spirit-stains: 30. Characteristics of spirit-stains. 31. Mixed spirit-stains and volatile oil-stains. 32. Evaporation and fire-risk. 33. Method of application. 34. Spirit-stains fade. 35. Procedure in staining. 36. Use of brushes and wiping. 37. Speed in staining.

CHAPTER VI. CHEMICAL STAINS 64

38. Definition of chemical stains. 39. Waning popularity of chemical stains. 40. Chemicals used in staining. 41. Necessary precautions when using chemical stains. 42. Preparation of the surface before applying chemical stain.

Page

43. Fumed-oak color with fixed alkalies. 44. The ammonia fuming process. 45. The fuming process on white oak. 46. The fuming-box. 47 Time required for the fuming process. 48. Testing for color. 49. Securing uniform results. 50. Procedure for fumed-oak finish.

CHAPTER VII. COLORS AND WOOD-STAINS 78

51. Colors used in wood-staining. 52. Definitions of terms. 53. Colors of the prismatic solar spectrum. 54. The three primary colors. 55. Secondary colors. 56. Tertiary colors. 57. Quaternary colors. 58. Complex mixed colors. 59. Neutral colors. 60. The color-circle. 61. Complementary colors. 62. Contrasts. 63. Color triads. 64. Color-harmony. 65. Analogous and contrasting colors. 66. The modern theory of color. 67. Acceptable color-combinations. List of good color combinations. 68. Palette of colors for staining.

CHAPTER VIII. DYES USEFUL AS STAINS 92

Dyestuffs and Dyeing: 69. Sources of Dyes. 70. Definition of dyestuff. 71. Theories of dyeing. 72. Mordants. Animal dyes: 73. Cochineal. 74. Tyrian purple. 75. Kermes. Vegetable Dyes: 76. Logwood extract. 77. Indigo. 78. Aloes extract. 79. Madder extract. 80. Gallnuts. 81. Cutch, or catechu. 82. Fustic. 83. Turmeric. 84. Osage orange. 85. Brazil-wood. 86. Red sanders, or red sandalwood. 87. Camwood bark. 88. Quercitron. 89. Patent bark. 90. Flavin, or flavine.

CHAPTER IX. COAL-TAR DYES AND THEIR USE AS WOOD-STAINS 104

91. Characteristics and origin. 92. All coal-tar dyes are not aniline dyes. 93. History of coal-tar dyes. 94. Products of coal-tar distillation. 95. Methods of classifying and naming synthetic dyes. 96. Crudes and intermediates for dyes. Chemist's classification of coal-tar dyes: 97. Azo compounds. 98. Triphenylmethane dyes. 99. Azine dyes. 100. Xanthene colors. 101. Anthracene or anthraquinone dyes. 102. Nitroso and nitro dyes. 103. Oxazine colors. 104. Acridine colors. 105. Thiazine colors. 106. Thiazole colors. 107. Quinoline colors. 108. Indigoid colors. Coal-tar dyes classified by application: 109. Acid dyes. 110. Basic dyes. 111. Salt, direct, or substantive dyes. 112. Mordant dyes. 113. Pigment dyes. 114. Developing dyes. 115. Sulphur dyes. 116. Vat dyes. 117. Oil-soluble wood-stains. 118. Classes of dyes used in wood-finishing. 119. Dyeing or coloring wood. 120. Solubility of dyestuffs and wood-staining materials. 121. Water-soluble colors. 122. Spirit-stains. 123. Oil-soluble dyes.

Page
CHAPTER X. WOOD-FILLERS 137

124. The purpose of fillers. Classes or types of fillers: 125. Transparent fillers. 126. Liquid fillers. Paste fillers: 127. Body materials in fillers. 128. Ingredients used in paste fillers. 129. Colored pigments used in producing special paste fillers. 130. Brushes and "picking-sticks" for filler. 131. Brushing and dusting wood before filling. 132. Sanding water-stained surfaces before filling. 133. Process of filling. 134. Rubbing paste filler. 135. Drying paste filler. 136. Sandpapering a filled surface. 137. Certain woods require a paste filler. 138. Paste fillers are best on floors.

CHAPTER XI. SPIRIT-VARNISHES 164

139. Spirit-varnishes defined. 140. Resins used in spirit-varnishes. Three useful soft gum varnishes: 141. Dammar-varnish. 142. Mastic-varnish. 143. Sandarac. Shellac-varnish—preparation, application: 144. Lac-gum. 145. Alcoholic solutions of shellac-gum. 146. Effects of metal cans and dust on shellac-varnish. 147. Orange and white shellac. 148. Use of shellac. 149. Drying and sanding shellacked surfaces. 150. Shellac-washes. 151. Methods of making shellac spread more easily. 152. Effects of moisture on shellac. 153. Good and bad qualities of shellac. 154. Rubbing shellacked surfaces. 155. Shellac substitutes. 156. Selection and care of shellac-brushes. 157. French polishing.

CHAPTER XII. ENAMELS AND ENAMELING 192

158. Paint-enamels and their functions. 159. Composition of enamels. Types of enamel: 160. Gloss enamels. 161. Polishing or rubbing-enamel. 162. Water-proof enamels. 163. Exterior enamels. 164. Satin-finish enamels. 165. Flat enamels. 166. Durability of enamels. 167. Undercoats and preparation for enamel finishes. 168. Enameling specifications and procedure. 169. A cheap enamel finish. 170. Refinishing old painted or enameled surfaces. 171. Application of enamels. 172. Covering-capacities of enamel and paint undercoats.

CHAPTER XIII. OIL OR OLEORESINOUS VARNISHES . . 212

History — Purpose — Classification — Composition: 173. Brief history of varnishes and varnish-making. 174. Purpose of varnish. 175. Classification of varnishes. 176. Composition of oil-varnishes. 177. Secrets of varnish-making. 178. Resins used in oil-varnishes. 179. Congo gum. 180. Kauri resin. 181. Pontianak. 182. Manila gums. 183. Rosin and resinates. 184. Ester gum. Drying-oils in varnishes: 185. Linseed-oil. 186. Tung-oil or China-wood oil. Varnish-thinners or volatile-oil solvents: 187. Turpentine. 188. Turpentine substitutes. 189. Driers and their functions in oils, varnishes, and japans.

Page

CHAPTER XIV. OIL OR OLEORESINOUS VARNISHES (Continued) 251

Types — Properties — Application — Rubbing — Removing: 190. Types of varnish. 191. Architectural varnish. 192. Automobile varnish. 193. Baking-varnish. 194. Coach-varnish. 195. Exterior varnish. 196. Enamel-varnishes. 197. Finishing-varnish. 198. Flat varnish. 199. Flat mixing-varnish. 200. Floor-varnishes. 201. Flowing varnish. 202. Furniture-varnishes. 203. Gear and chassis varnish. 204. Gloss-oil varnish. 205. Grinding-varnishes. 206. Hard-oil varnish. 207. Heat-proof varnish. 208. Interior varnish. 209. Insulating varnish. 210. Long-oil varnish. 211. Marine varnish. 212. Mixing-varnish. 213. Piano-varnish. 214. Polishing-varnishes. 215. Rubbing-varnishes. 216. Sizing-varnishes. 217. Short-oil varnishes. 218. Spar-varnish. 219. Spraying-varnishes. 220. Water-proof varnishes. 221. Working and thinning properties of varnishes. 222. Luster, elasticity, and color of varnishes. 223. Necessary preparations for varnishing. 224. Application of oil-varnishes. Rubbing the coats of varnish: 225. Rubbing with water-proof sandpaper. 226. Rubbing with oil and sandpaper. 227. Rough rubbing with lump pumice-stone. 228. Dull-finish rubbing with pumice-stone powder and water. 229. Satin-finish with rubbing-oil and pumice-stone. Polishing processes: 230. Polishing with rottenstone and water. 231. Polishing with rottenstone and oil. 232. Polishing-oil formulas. 233. Spiriting-off or French polishing with alcohol. 234. Varnish-removers. 235. Formulas for paint and varnish removers. 236. Cleaning varnish-brushes.

CHAPTER XV. LACQUERS—HISTORY, USES, AND COMPOSITION 285

237. Brief history of lacquers. 238. Uses for lacquers. 239. Composition of nitrocellulose lacquers. 240. Nitrocellulose, soluble cotton, or pyroxylin. 241. Varnish-resins used in lacquers. 242. Solvents for nitrocellulose and resins. 243. Plasticizers and softeners. 244. Diluents or thinners. 245. General formula for lacquer. 246. Clear brushing-lacquer for wood. 247. Formula for high-grade spraying-lacquer. 248. Clear or transparent lacquers. 249. Lacquer-enamels and colored lacquers.

CHAPTER XVI. LACQUER FINISHES AND LACQUER TECHNIC 319

250. Advantages of lacquers over varnishes and enamels. 251. Disadvantages of lacquer-finishes. 252. Undercoats for lacquers. 253. Application of lacquers. 254. Spreading lacquer with a brush. 255. Spraying lacquer with an air-gun. 256. Drying of lacquers. 257. Sanding, rubbing, and polishing lacquer-films. 258. Flat lacquers and waxed lacquer-finishes. 259. Mixture of shellac and lacquer.

Page
CHAPTER XVII. PAINT AND PAINTING 339

260. Brief history of paint and painting. The functions of paints: 261. Obscuration and decoration. 262. Preservation of materials. 263. Sanitation and cleanliness. 264. Improved lighting-effects. Composition of paints: 265. Pigments. 226. Vehicles. 267. Thinners. 268. Driers. 269. White lead. 270. Properties and uses of white lead. 271. Zinc white. 272. Lithophone. 273. Titanox and titanium oxide. 274. Antimony oxide or white antimony. 275. Barytes or barium sulphate. 276. Whiting or calcium carbonate. 277. Magnesium silicate or asbestine. 278. Silica or silex. Black pigments: 279. Lampblack. 280. Carbon black. 281. Bone or ivory black. 282. Charcoal black. 283. Graphite. Red pigments: 284. Venetian red. 285. Indian red. 286. Tuscan red. 287. Red lead. 288. Other red pigments. 289. Orange-red pigment. Yellow pigments: 290. Yellow ocher and golden ocher. 291. Chrome yellow. 292. Raw sienna. 293. Other yellows. Blue pigments: 294. Ultramarine blue. 295. Prussian blue. 296. Cobalt blues. Green pigments: 297. The earth greens. 298. Chrome or Brunswick green. 299. Other green pigments. Brown pigments: 300. Raw umber. 301. Burnt umber. 302. Vandyke brown. 303. Metallic pigments. 304. Characteristics of paint ingredients. 305. Pigment-pastes. 306. Paint-mixing by a painter. 307. Formula for mixing paints. 308. Mixing or blending colors. 309. Application of paint. 310. Number of coats of paint. 311 Priming. 312. Putty and puttying. 313. The body-coat, or second coat. 314. The third or finishing coat. 315. Hints and precautions for painters. 316. Care of paint-brushes. 317. Care of painters' rags.

CHAPTER I

PREPARATION OF THE SURFACE OF WOOD WITH PLANE AND SCRAPER

1. Wood Must Be Dry.—The seasoning of wood until it contains the proper amount of moisture is an important factor in successful wood-finishing. Wood that is to be used indoors should be kiln-dried to about 5 per cent of moisture as a final stage in seasoning, and then it should be allowed to stand for a time in a dry room where it will reabsorb a small amount of water from the air, thus equalizing the per cent of moisture in the wood with that of the air in the shop.[1] A finish which would not show checks, wrinkles, or other defects would have to possess very unusual qualities of elasticity were it to be placed on a piece of wood that is too moist, and which later on shrinks as the dampness dries out. For permanence of finish and lasting qualities of construction, wood must be properly seasoned and remain in a proper shop-dry condition during the construction and finishing periods.

Articles which are made from wood that has received only air seasoning at ordinary temperatures are usually unsatisfactory. The woodworker is likely to be blamed for loose joints, and the wood-finisher for poor workmanship or material. The real blame should be put on the excess of moisture in the wood, but this trouble-maker always escapes and goes into thin air and possibly condenses where it may cause more damage. Tests[2] of the moisture content of lumber which is used in shops should be made occasionally, especially when new shipments of lumber are received, because this information will show whether or not the material is safe for use. Even kiln-dried lumber must be kept in a very dry place or it will reabsorb moisture to such an extent as to be unfit for any important construction.

---

[1] See A. C. Newell, *Wood and Lumber*, Chapters VIII, IX.

[2] See A. C. Newell, *Wood and Lumber*, "How to Find the Moisture-Content of Wood," pp. 119-123.

2. Use Great Care in Preparing the Surface.—Beauty of finish depends to a great extent upon knowledge of how a surface should be prepared and the skill which is used in carrying out definite plans. Knowledge of the characteristics of the woods used and of the tools that are available is like good management at the head of a factory. If a workman knows considerable about the structure of wood, and its mechanical and chemical properties, he is not so likely to decide upon poor plans. On the other hand, he must have proper tools and equipment for preparing the surface and know how to use them skilfully. Finally, the real craftsman must have a valuable ethical quality known as honesty of purpose, and a perseverance which will bring creditable results.

If a hand magnifier or microscope, magnifying about 18 times, is turned on a piece of so-called smooth wood, the surface which was supposed to be smooth is found to be rough; sometimes very rough, in the case of ring-porous woods such as oak, Fig. 1. A few minutes of microscopic study will prove to any one that it really takes very great care to produce a smooth surface on a piece of wood. The broken fragments of wood cells under a strong glass sometimes look like the tree trunks of "down timber" on a burnt over area on a mountainside or great plain. The coarser defects of an improperly-finished surface are easily visible and objectionable to the ordinary eye, but a microscopical examination sometimes reveals undreamed-of roughness on a carelessly-scraped or inadequately sanded piece of wood.

No surface is ready for the wood-finisher that shows marks made by the machine-planer in dressing or surfacing the board to thickness. Such marks cannot be sanded out by hand, but must be carefully removed by a smoothing-plane, or scraped out by a scraper-plane; or both may be used to advantage on some woods. Sometimes fragments of fibers are torn out by a machine or hand plane leaving

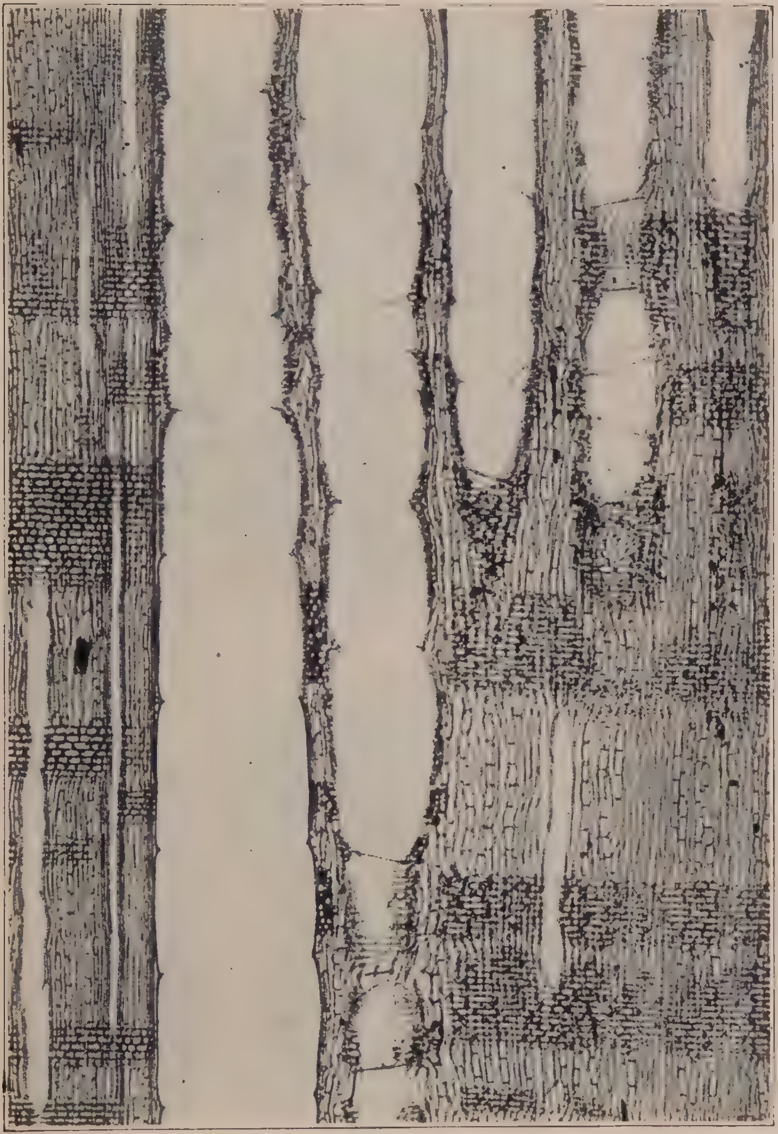


FIG. 1—QUARTER-SAWED RED OAK

A magnification of 50 diameters shows roughness and fragments of torn tissue about the large open pores or tracheal vessels which have been cut open lengthwise. Most of the roughness has been removed from the surface of this section. Photomicrograph furnished thru the courtesy of the Forest Products Laboratory, Madison, Wisconsin.

ragged rough spots. Such places must be scraped out, or may be removed by a sanding-machine. Hand-sanding will not remove such defects, and only a novice will attempt such a procedure.

3. Planing the Surface by Hand.—The first operation in the preparation of the surface of a piece of wood is, usually, planing with a hand-plane, using a smooth-plane after the rougher parts have been gone over with a jack-plane. Edges are frequently finished with a jointer in order to have them as straight as possible. In school and home shops where it is not practicable to have a plane for each purpose the most satisfactory all-round plane for general use is an iron jack-plane, about 14″ or 15″ in length, with a 2″ cutter. For children in the grades the junior jack-plane or smooth-plane may be substituted for the standard jack-plane in case the pupils are too small to use the larger plane without undue effort.

Plane-bits for smoothing surfaces should have straight edges, with rounded corners, ground to a bevel of about 22½°. Cutters used for very hard wood may be stiffer, and are often ground to a 25° or even 30° angle in extreme cases. If the surface is to be scraped after planing, the edge of the plane-bit may be very slightly curved, as in a jack-plane. The troughlike places made on a surface by such a plane can be removed later by proper scraping. Dull bits never cut smoothly and are a frequent cause of rough surfaces, torn-out fibers, and broken flakes and knots. A dull plane-bit sometimes does serious and almost irreparable damage before the cause of the trouble is discovered. Plane-bits require frequent sharpening when used on hard woods. The plane-iron cap sometimes requires sharpening, and should always fit perfectly on the cutter.

A smoother, sharper, and better cutting-edge can be put on a plane-bit if a strap is used for the finishing touches. A very practical strap for this purpose can be made by gluing to a board a piece of leather belting about 4″ by 12″ in size. Such a strap sharpens a tool better if very fine emery dust and cup grease are worked into the surface of the leather. If properly used on a plane-bit, the strap improves the cutting qualities as much as a razor-strap improves a razor after honing.

The plane-cutter should be carefully adjusted in the stock before planing is attempted. For fine finished work the plane-iron cap should be set close to the edge, about 1/32″ back, and should be firmly clamped with the edge of the plane-bit parallel to the edge of the plane-iron cap.

The frog of the plane should be slightly advanced for smooth work, and placed so that the opening in the throat in front of the cutter is less than is ordinarily used in a jack-plane. The small throat and close adjustment of the plane-iron cap prevent to some extent the tearing out of irregular fibers or those that run against the grain.

Holding the plane when in use so that the side of the plane-stock is at an angle of from 10 to 20 degrees to the edge of the board causes the cutter to make a shearing cut, which usually leaves a smoother surface than when the parallel position of the plane is used. It is easier to secure a flat surface across grain when the plane is held in this position. Turning a plane to an angle has one disadvantage, however, in that it shortens the useful length of the plane from end to end or lengthwise of the piece.

Strokes made the full length of the piece should be taken whenever possible, as this avoids uneven places which are always produced when the plane is started *on* the piece instead of at an end. Stopping the plane anywhere except at the farther end of the piece may produce similar uneven places, but they are not usually as serious. Skilful workmen always plane with long, even, full strokes. For such finishing work the plane should be adjusted so that it will cut thin shavings of even thickness. In other words, the cutting edge should be parallel to the plane-bottom. This adjustment should be made with great care before any planing is attempted.

The hand-planing operation should not be omitted on any surface which is to be finished with transparent finishes, unless it is decided that a scraper-plane should be substituted for the smooth-plane, on account of unusual grain, such as that found in curly birch, bird's-eye maple, or quarter-sawed oak. A scraper-plane properly handled will cut against the grain more satisfactorily by far than a smooth-plane, and is a much better and safer tool to use on twisted or unusual grain of any kind.

Inexperienced workmen, especially children in schools, sometimes get in a hurry, and try to dodge the planing operation which is used to remove roughness including the marks of the machine-planer in the case of dressed lumber. Sometimes attempts are made to scrape a surface with a hand-scraper instead of using a plane or scraper-plane. The hand-scraper usually follows the irregularities or waves of the board and does not level the surface at all. Attempts to smooth a machine-planed surface with sandpaper alone are always very expensive of time and result in failure. Sandpaper follows the waves made by the machine-cutter and does not smooth properly or level the surface. Such unworkmanlike methods of procedure brand a person as a novice with little knowledge or experience.

4. Scrapers and Their Use.—Scrapers when properly sharpened and used are a great source of satisfaction to a workman and perform work that is usually surprising to an amateur. In shops where a machine-sander is not available to smooth and level surfaces of wood, scrapers are very important tools.

There are two different kinds of scrapers: (1) scraper-planes, and (2) cabinet-scrapers or hand-scrapers.

Scraper-planes are tools which hold scraper-blades or cabinet-scrapers in stocks, which in some of their forms, resemble plane-stocks. The Stanley Numbers 12, 112, and 80 are examples of scraper-planes or holders that are very satisfactory.

Scraper-blades for use in scraper-planes or holders are usually sharpened with a beveled instead of a square edge. The procedure is as follows:

(1) Remove the old hook by honing the blade, which should be held with its flat side on the stone. Never use a file for this purpose, as the side of the blade will become scratched, and these scratches will make nicks in the new hook.

(2) File a bevel on the blade at an angle of about 30°, using a 10″ or 12″ mill-file. Round the corners slightly, as in grinding a plane-bit. The bevel may be ground on a grinder if one is convenient.

(3) Whet the edge with great care on an oilstone. Any feathered edge may be removed by cutting into a piece of wood, using the blade like a chisel, but drawing the edge across the fibers of the piece as with a knife. Repeat this operation until the blade is sharp and the feathered edge is removed. It is not usually possible to get as sharp and smooth an edge on a scraper-blade as on a plane-bit. Finish the sharpening process by the use of a strap as in sharpening a plane-bit.

(4) Place the scraper-blade in a vise, or preferably in a special clamp or kit made for the purpose. Take a large burnisher made of specially hardened steel, and turn a hook on the edge of the bevel, bending the metal over toward the flat or front side. Use about five strokes, turning the hook more each time, and holding the burnisher at an angle of about 95° or 100° with the face of the blade on the last stroke.

A scraper-blade sharpened as described above, if properly adjusted in the scraper-plane, will cut thin long shavings, and will plane against the grain to some extent without tearing out the fibers. A scraper-plane will make a very much smoother surface on most woods than will a smooth-plane. On some very hard, crooked-grained woods the smooth-plane should not be used, the scraper-plane being substituted for the entire planing process in order to avoid tearing out fragments such as flakes in oak and the eyes in bird's-eye maple, Fig. 2.

A dulled scraper-blade hook can sometimes be flattened out part way back with a burnisher and then turned over again as in the first turning of the hook.

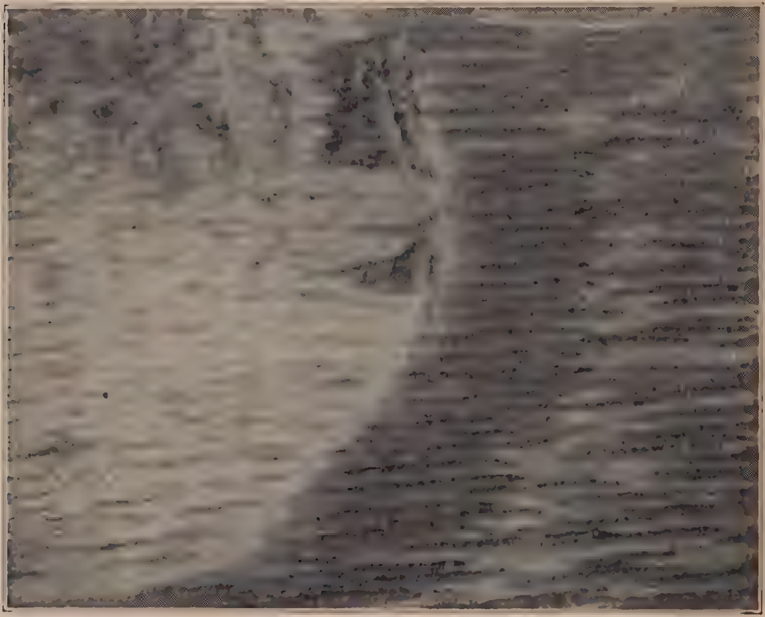


FIG. 2—SURFACE OF CHESTNUT WOOD SHOWING TORN FRAGMENTS
Fragments of wood have been torn out because of planing against the grain. The surface was improperly scraped. Note the filler in the open pores. Magnification is about 5 diameters.

The cabinet-scraper usually has two square edges for cutting instead of one beveled edge. It is not possible to turn a large hook on square arrises, but a very sharp fine edge or burr can be secured that is excellent for finishing a surface by hand.

The method commonly used for sharpening a square edge on a cabinet-scraper is as follows:

(1) Hone off the old hooks by placing the scraper-blade flat down on an oilstone and whetting till the old hook is gone.

(2) With the edge that is to be sharpened up, or on top, clamp the scraper-blade in a vise.

(3) File a square edge on the blade with a 10″ or 12″ mill-file having rather fine teeth for cutting. File from edge to edge rounding off the two corners slightly as in a plane-bit.

(4) Draw-file the edge by holding one end of the file in each hand, and filing back and forth toward the corners keeping the file at right angles to the blade. The file is pushed with the arrises to be sharpened, not against or across them.

(5) Hone the sharpened edges holding the blade perpendicularly against an oilstone. Also hone each flat side with the blade flat down on the stone. Repeat the processes until the edges are square and sharp.

(6) Turn the square cutting-edges down to about 85° with a large smooth burnisher, holding the blade firmly in a bench-vise. Use about four strokes in turning, increasing the pressure and decreasing the angle with the face side each time.

The small sharp burr or hook on a cabinet-scraper will do wonders in smoothing up defective places that cannot be removed with sandpaper.

A few of the coniferous woods such as cypress and some very soft woods do not scrape well. On such woods the scraping operation should be omitted. The soft woods which cannot be scraped satisfactorily usually can be smoothed very effectively with a sharp plane; scraping in such cases is not important and should not be attempted. The plane-cutter which is used for planing surfaces that are not to be scraped must be properly ground with a straight edge and round corners. A jack-plane cutter with its slightly curved edge is unsatisfactory for such planing.

Curved scrapers can sometimes be used to advantage especially for smoothing concave surfaces. A scraper-blade may be filed or ground to the desired shape, and then sharpened with a hook similar to that put on a square scraper. A beveled-edge hook is frequently put on curved scrapers. A scraper of this kind is often helpful in smoothing up surfaces which are made with a gouge.

5. Plugs and Cement for Holes and Cracks.—Various small defects such as worm-holes, knot-holes, dents, torn fibers in small spots, and places that have been injured by tools or in some other way during the process of construction, are frequently found on otherwise perfect surfaces, and must be repaired. If the injury is large, as a knot-hole extending thru the board, it is frequently best to insert a plug of wood and to glue it into place. Sometimes bad defects can be chiseled out, and a piece of wood having similar grain and color can be so carefully inlaid and glued into place that it will hardly show when finished. This kind of repair takes more time than other processes, but is permanent, and causes less disfigurement to the piece if done skilfully.

Another process now commonly used in factories is to fill the defective place with cabinet-maker's cement.[3] This material is made for furniture factories, and comes in bricks having a color resembling wood. In use, fragments of cement are broken up, melted, and thinned with water to a thick paste which can be pressed into the defect with a putty-knife. The opening should be filled slightly too full when first put in place and sanded level after it has dried. The spot of cement will usually take stains nearly the same as the wood itself. If the cement is used on a dark-colored wood, or put in a spot in a cedar chest, the cement should be stained to the proper color with dry pigments before it is used. There are also water putties on the market that can be made into paste with cold water and pressed into place with a putty-knife.

An old method for repairing small defects is to secure some fine dust from sanding the surface of the wood which has the defect. This powder is then mixed with a liquid cold glue, making a paste which can be pressed into place with a putty-knife. When dry the spot can be sanded. A repaired place of this kind filled with glue paste will not stain well. Paste can be mixed with dry colors, however, while in the wet form and made nearer the proper color. Glue paste should be quite thick, and in use should not be spread over the surface of wood around the defect because glue sizes wood and prevents stain from ''taking'' when the article is stained later on.

---

[3] See Grand Rapids Wood-Finishing Company, *Better Wood-Finishing*, p. 3.

Melted wax from shellac sticks may be run into small defects. This is usually done after the article is partly finished so that the color can be matched to better advantage. Shellac sticks in various colors can be purchased from supply-houses for furniture wood-finishing.

Dents can sometimes be removed by steaming with a wet cloth and a hot iron. Hot water alone if put into a dent several times will sometimes swell the compressed fibers back to normal condition and thus practically remove the unsightly spot. A putty-knife, if carefully heated about as hot as a flat-iron when used for ironing, will help to raise a dented spot if placed over wood that has been well moistened with water. In all of these cases the wood fibers are swelled by steam and are likely to assume nearly their original shape, thus causing the dent to disappear.

REFERENCES—CHAPTER I

Preparing the Surface of Wood with Plane and Scraper

L. A. Crocker, Industrial-Arts Magazine, Vol. II, No. 1, p. 24, July, 1914.
Furniture Manufacturer Magazine, Vol. XX, No. 4, p. 194, October, 1920, "On Sharpening the Cabinet-Scraper."
Grand Rapids Wood Finishing Company, *Better Wood-Finishing,* Chapter III.
H. R. Jeffery, *Wood-Finishing,* Chapter I, pp. 9-16.
A. A. Kelly, *Expert Wood-Finisher,* "Putties and Cabinet-Maker's Cement," pp. 75-6.
A. C. Newell, *Wood and Lumber,* "Seasoning and Moisture-Content of Lumber," Chapters VIII and IX.
W. K. Schmidt, *Problems of the Finishing-Room,* Chapter IV, pp. 39-40. "Filling Holes with Stick Shellac, p. 123."
F. N. Vanderwalker, *Wood-Finishing, Plain and Decorative,* pp. 17-31.

CHAPTER II

SURFACE ABRASIVES AND THEIR USE

6. Inspection Before Sandpapering.—Inspection of the surfaces to be sandpapered is an important preliminary which should never be overlooked. If rough spots or planer-marks have been left they should be found and removed before any sanding is attempted. Hand sandpapering will not remove or cover up defects of this kind. It always wastes time and increases the difficulty. Scraping out the unfinished places later on is harder because sandpapering always leaves sand in the pores of the wood, and this sharp grit soon dulls the edge of a scraper-blade. Very frequent sharpenings of the hook on a scraper are necessary, if scraping is attempted after wood has been sandpapered.

Amateur wood-finishers should learn what defects to look for, and should realize that planer-marks and minor blemishes that hardly show on the natural wood are greatly exaggerated on the finished piece, especially, if stain of any kind is used. Rough surfaces practically always expose more cross-sections of the pores or end grain, which, when stained, will show darker than the rest of the surface. This is due to the fact that the end grain of wood is always more porous than the ordinary grain of longitudinal or transverse sections.[1] See Fig. 3.

7. Sandpaper Manufacture.—Sandpapers of the present day are not made from sand and paper. The grit which looks like sand is made from quartz or flint rocks. The red or garnet papers have a grit made from garnet ore. Great hardness and sharpness of edges are important factors in a grit. Natural sand, while hard, has few sharp edges, as all such cutting places are soon worn off and smoothed by rubbing against each other, just as rocks on the mountain sides are smoothed and rounded by glacial action. Sharp grit is made from crushing hard rock and sifting in order to secure particles of uniform size. Various sizes of rock fragments, sometimes called sand, are secured in order that sandpaper of different grades of coarseness and fineness may be manufactured.

---

[1] See A. C. Newell, *Wood and Lumber*, Chapter III, "Wood Cells."

The best grades of paper are strong, especially when made from Manila fiber which is sometimes secured from old ropes, and the strength is also increased by a crisscross or uneven arrangement. Papers which are made so that the fibers are not parallel with their lengths in one direction are stronger crosswise and have nearly uniform strength in every direction. Such papers are difficult to tear and, if torn, leave a rough uneven edge. Thicker papers are used when coarser grits are to be applied.

In the manufacture of sandpaper, rolls of paper run thru a machine, unwinding and passing along as in a printing press. Hot glue of a good grade is spread evenly over one side of the paper. The sand is then sprinkled to a uniform thickness over the surface, and the excess grit which does not become set in glue finally disappears falling off after the paper turns over a roller. In order to make sure that the sand will stick to the paper more glue, this time in thin solution, is applied, and then a drying process with a hot blast is begun. When the glue becomes set or practically dry the paper is rolled up, or cut into sheets of standard sizes.

Some manufacturers are now producing a new type of double-coated paper, known as split sandpaper, which has a layer of sand or grit on both sides. This paper will easily split apart, leaving two sheets of sandpaper, each being very thin and flexible. Such an abrasive is excellent for smoothing curved surfaces, because it can be more easily bent over one's hand or in a curved form than is the case with ordinary sandpaper.

The Wetordry Garnet Finishing Paper[2] is another sand-

---

[2] Manufactured by the Minnesota Mining and Manufacturing Co., St. Paul, Minn.

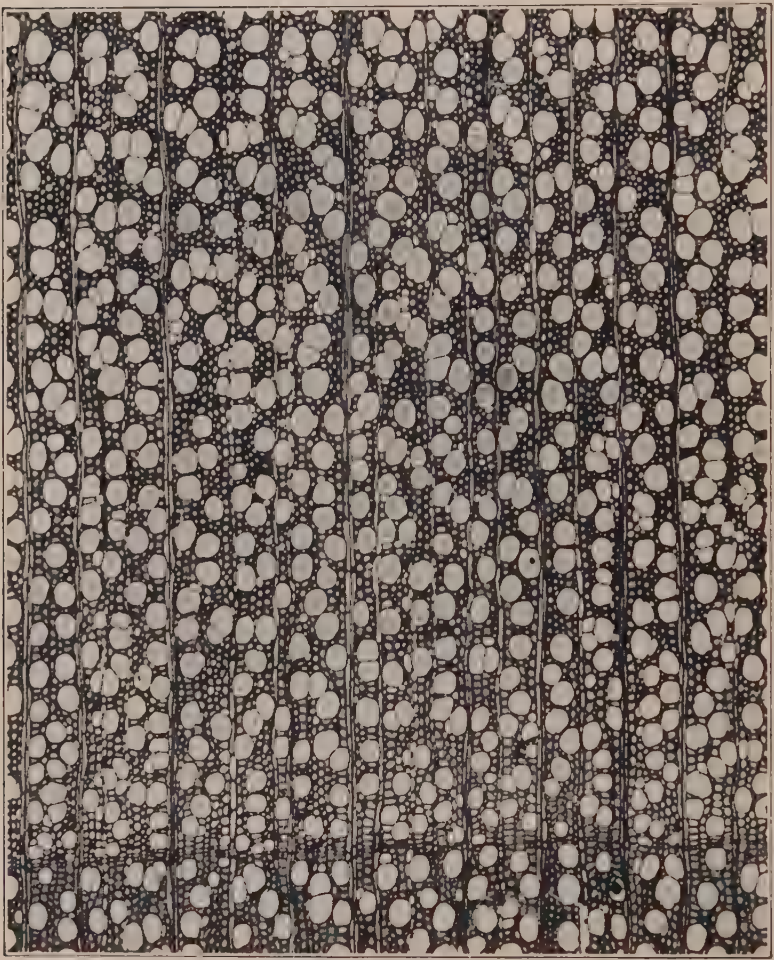


FIG. 3—END-GRAIN OF RED GUMWOOD

This cross-section of the wood of the red gum shows the porosity of the end-grain of a close-grained wood. Magnification about 50 diameters. Courtesy of the Forest Products Laboratory, Madison, Wisconsin.

paper that has some excellent features very desirable in wood-finishing, for this paper is waterproof, and can be used to great advantage over a wet felt pad. The finer grades of Wetordry sandpaper, such as the 5/0 to 8/0 sizes, are excellent for sanding varnish between coats. A varnish surface smoothed with one of these papers having the finest grit looks much like a finish rubbed with pumice-stone, and the operation can be completed in much less time.

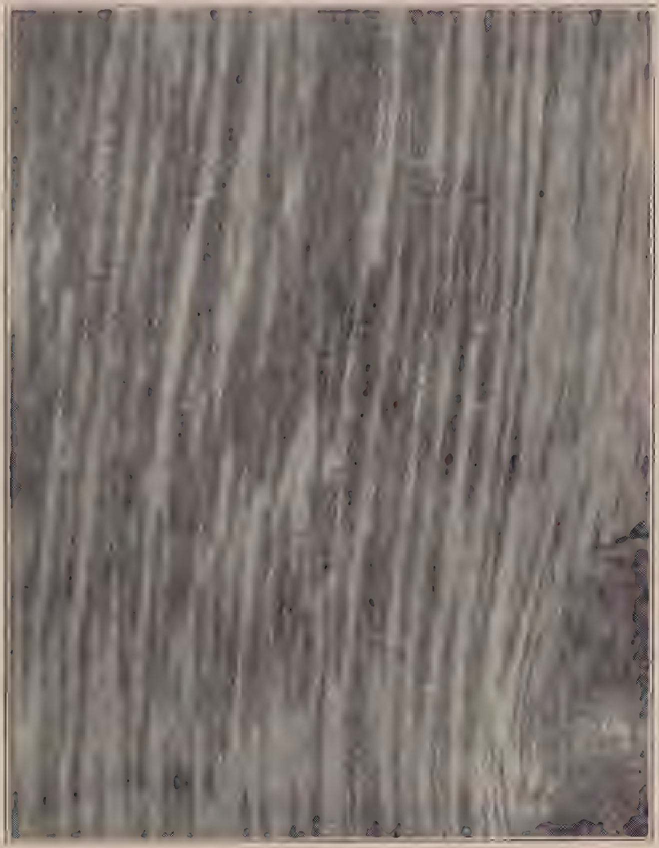


FIG. 4—PROPERLY SCRAPED AND SANDED SURFACE OF CHESTNUT

The pores of the wood have been successfully filled with paste wood-filler. The magnification is about 5 diameters.

8. Sizes of Sandpaper.—Many sizes of grit are used in manufacturing sandpaper, ranging from 8/0 to 4, as follows:

(1) *Very fine or soft papers,* used by wood-finishers: from 00000000, or 8/0, to 00, or 2/0.

(2) *Medium sizes,* commonly used by woodworkers: 0, or 1/0, 1/2, 1, 1½, 2.

(3) *Very coarse papers,* more commonly used on sanding-machines for rapid cutting: 2½, 3, 3½, 4.

Sizes finer than 8/0 sandpaper are made by some manufacturers, but are not commonly found on the market.

Unfortunately, the sizes of sandpaper are not absolutely standardized, and one manufacturer's sizes may not correspond exactly with those of another.

9. Use of Sandpaper.—The cardinal principle in the use of sandpaper is that *all sanding must be with the grain,* Fig. 4. Never make circular, cross-grain, nor oblique strokes with sandpaper, as scratches always result. End-grain of wood must be sanded crosswise. A careful study of wood structure with a magnifier shows that the fibers are arranged like parallel tubes lengthwise of the grain.[3] These fibers are scratched, torn, or cut thru by the sharp edges of the sand grit if the strokes are in any other direction than lengthwise of the grain. Resanding with the grain in the proper way will not easily remove scratches. Such injuries should be scraped out, and after all scratches have disappeared, the surface should be sanded, pushing the sandpaper lengthwise of the grain of the wood.

Blocks for holding sandpaper in order that greater pressure may be applied are used in every finishing-room. The size, weight, and covering for the blocks depend upon the kind of work. For big surfaces a rather large heavy block has some advantages. A brick covered with canvas or other cloth is used in some shops for coarse work, especially where rapid cutting on large surfaces is desired. For the first sanding with coarse sandpaper some workmen prefer a hard flat block with little or no covering. Sandpaper over a hard block without covering, or with little covering, will cut off the high spots better and help to reduce the somewhat irregular surface to a truer, leveler, or plane surface. A favorite size of sandpaper for use on many kinds of wood for the first sanding is No. 1 or 1½. For the finer-grained woods one should use the No. 1, which is finer than No. 1½.

---

[3] See A. C. Newell, *Wood and Lumber,* "Tracheal Vessels and Tracheids," pp. 34, 35.

The second sanding with finer paper can best be done with a soft block or a block with a soft cover. Corks about 1″ x 3″ x 6″ in size are preferred by some; another size sold on the market for such work is 1″ x 4″ x 4″. Felt-faced or cloth-covered blackboard erasers can be used very satisfactorily for sanding-blocks. Some finishers use rubber-faced blocks. A home-made block of this kind can be prepared from a rectangular scrap of soft wood to which is tacked a piece of rubber taken from an automobile inner tube. The sizes of sandpaper used for fine sanding are about ½ or 0. Sometimes 00 paper is preferable for very fine-grained hard wood.

Rounding off the corners of a piece of wood in sanding is a very common fault that must be avoided, or the appearance of the finished work will be ruined. This does not mean that the sharp feathered edges or arrises should not be slightly smoothed off to get rid of slivers, for this should always be done with fine sandpaper in the final sanding. Unless care is taken to avoid a rocking motion while sanding, corners and edges will become rounded off unevenly, and unsightly disfigured work is the result.

End-grain sanding is just as important as sanding of the surfaces and edges. If the end-grain is left too rough, additional stain will be absorbed there; consequently it will become darker than other portions of the surface.

Curved surfaces can be sanded to best advantage with split sandpaper, as described on p. 27. Double-coated paper for splitting is now sold on the market. The split sandpaper is most effective for some kinds of work when dampened or moistened on the back. Water, benzine, and turpentine, or turpentine substitutes, are used for moistening sandpaper either to keep down dust or to make the paper more pliable.

The use of sandpaper between the successive coats of finish is necessary in securing a level surface and proper adhesion of the films of shellac, varnish, or lacquer that are to be applied later on in the finishing process. The kind and size of sandpaper, and the method of using it, depend upon various conditions. Three types of sandpaper are used by wood-finishers: (1) standard paper, with either flint or garnet grit; (2) split or double-coated paper; and (3) waterproof sandpaper. The standard and split types have already been described in previous paragraphs of this section.

Water-proof sandpapers have been developed to help solve several problems of the finishing-room. The use of such papers enables a workman to sand a moist surface of wood soon after it has been sponged thereby saving a certain amount of time. Sanding with wet paper reduces the dust in the room which helps to preserve the health of the finisher and to reduce danger of specks in varnish finishes. For sanding moist wood to remove fuzz, rather fine grades of grit, such as sizes ½, 0, or 00, should be used in most cases. Waterproof papers, which do not lose their grit when thoroly dampened and kept in that condition during several minutes, are often preferred for rubbing between coatings of varnish; and, when used over a rubber or felt block, they produce a level surface without gloss, more quickly and more satisfactorily, between the first coats especially, than does pumice-stone. The sanding should all be done lengthwise of the grain only, where this is possible, and fine grades of grit, such as the 5/0 to 8/0, leave an excellent surface for refinishing.

Automobile painters are using a special sandpaper which can also be used wet. Automobile finishers' sandpaper is sold by number; such as No. 280, rather coarse; No. 320, medium in grit; and No. 400, very fine. These sandpapers are used for smoothing undercoats and surfaces of lacquer which must be made level in preparation for the next coat.

They scratch if they are used dry, and for this reason they are kept wet when rubbing varnished or lacquered surfaces.

10. Steel Wool and Its Use.—Steel wool is often used to advantage in smoothing concave surfaces. The sizes of steel wool most commonly used are: 000 or 3/0, 00 or 2/0, 0, 1, and 2; 000 being the finest, and No. 2 the coarsest. Cartons or packages of steel wool in 1-pound, 5-pound, and 10-pound sizes are sold on the market by hardware stores, and paint and varnish supply-houses. Its cost at the present time varies from 40 cents to $1.00 a pound, the finer grades being the most expensive. In use, a ball or wad of steel wool is taken in the hand, and the surface is rubbed as with sandpaper. Strokes should be made with the grain whenever possible, as scratches will result if the abrasive is used crosswise or obliquely. Steel wool is not at present as uniform in fineness of grit as sandpaper, and is much more liable to make scratches; especially, if attempts are made to use it on flat surfaces.

11. Sponging and Resanding.—Beauty and clearness of grain can be secured by sponging with water. This is done in order to dampen and raise the grain on all surfaces that are to be finished. Sponging the surface may be done with a wool sponge, an ordinary sponge, or with a soft large brush that holds water well. The wood should be dampened enough to cover all of the wood fibers on the surface with water, yet with not enough to leave a layer or coating that takes considerable time to dry. An excess of moisture might injure glue joints particularly those of veneer.

Fuzz appears over the entire surface of any piece of wood that has been sponged and allowed to dry. The surface of a piece of wood consists of cells[4] which are something like long tubes running lengthwise of the grain. Many of these cells are cut thru, exposing the ragged walls, when the processes of planing and scraping are done, Fig. 5. Some of this roughness, however, is removed by sanding. The finest sandpaper does not remove all the fragments of

---

[4] A. C. Newell, *Wood and Lumber*, Chapter III, "Wood Cells."

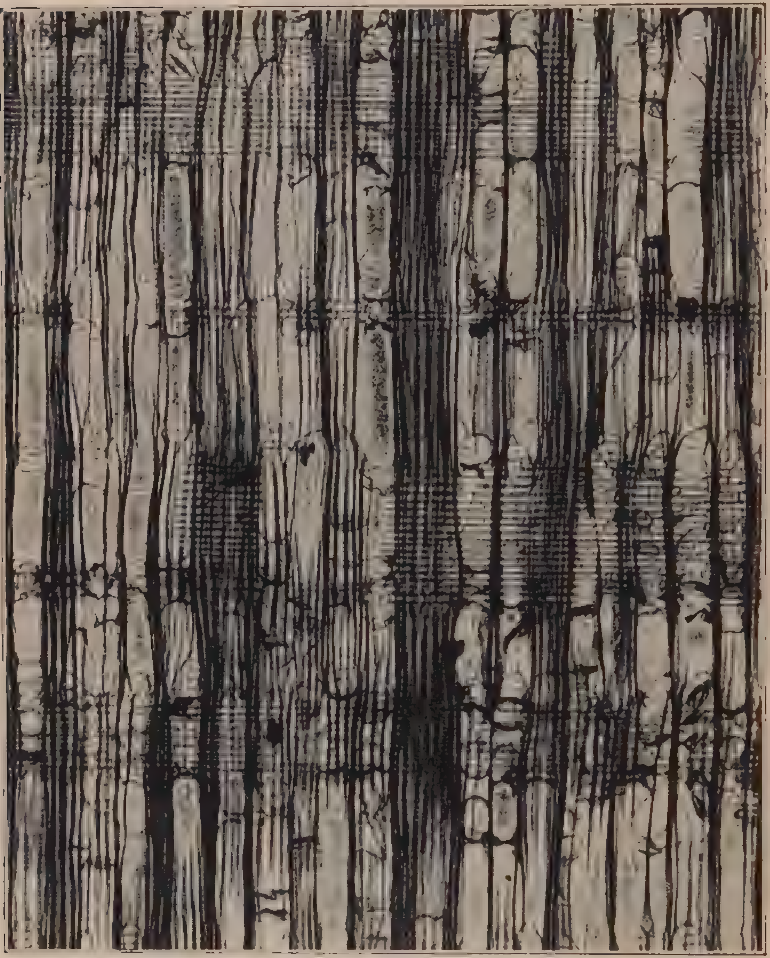


FIG. 5—CELLULAR STRUCTURE OF WOOD

Radial section of yellow poplar, a wood of fine grain; the edges of the cell walls have been cut thru in many places, and these broken walls will leave ragged fragments of tissue on the surface. Sandpaper should be used lengthwise of the grain in order to remove all roughness from the broken cell walls. Magnification, 50 diameters. Courtesy of the Forest Products Laboratory, Madison, Wisconsin.

the cell walls. Some of these particles are more or less loose after sanding, and swell up and stiffen as a result of sponging and drying, and become the fuzz that can be felt on a sponged board after it has dried. The fuzziness on the surface of wood that has been moistened can largely be removed by resanding with fine sandpaper. The best results are secured by using 2/0, 3/0, or even 4/0 sandpaper over a block, as described in the first sanding operation.

Careful use of sandpaper, using long full strokes lengthwise of the grain, leaves the surface in a very smooth condition. Sponging, and resanding a second time very slightly improve the surfaces of some kinds of wood, but not enough usually to pay for the trouble. Sponging and resanding are always necessary if water stains are used because these operations prevent the stain from raising the grain or fuzz. If stains that do not contain water are used in the finish, the sponging and resanding operations are usually omitted on account of the cost of the extra work required.

Excessive use of water in sponging, and excessive pressure on the sandpaper, should both be avoided on veneered work, or spots may be cut thru which cannot be repaired without reveneering. Veneer[5] is thin, being ordinarily about 1/20″ in thickness, and part of this is always removed in the first sanding operation. Hard pressure and coarse sandpaper should never be used in smoothing veneered wood.

12. Dust Sanded Surfaces.—The last operation in the preparation of the surface of wood should be a thoro dusting with a stiff bristle brush that will remove all dust and broken fragments and much of the sand from the pores of the wood. The brushes commonly used for this purpose are called picking brushes. If the wood is to be filled with wood-filler, the dusting operation is of considerable importance, because it cleans the surface and opens up the cavities of the cells or pores; and, at the same time, it removes any loose gum or other waste matter[6] that may have been left in the cell lumina as end-products of food growth or digestion. Picking brushes should be used on open-grained woods for dusting, but close-grained woods that require no filler may be dusted with any coarse dusting-brush.

---

[5] A. C. Newell, *Wood and Lumber*, "Veneers and Plywood," pp. 189-197.

[6] Ibid., Chapter V, "Waste Products," pp. 56-61.

Dust will settle on any article in a few hours' time; consequently every piece of wood should be dusted just before any wood-finishing process is started, and just before any later coat is applied.

REFERENCES—CHAPTER II

SURFACE ABRASIVES AND THEIR USE

Grand Rapids Wood-Finishing Company, *Better Wood-Finishing,* Chapter III.

H. R. Jeffrey, *Wood Finishing,* Chapter I, pp. 13-14.

A. A. Kelly, *Expert House-Painter,* "Sandpaper and Its Uses,"—pp. 139-142.

A. A. Kelly, *Expert Wood-Finisher,* "Chapter on Information," "General and Special," pp. 275-6; "Raising the Grain," p. 94.

A. C. Newell, *Wood and Lumber,* "Wood Cells," pp. 28-49; "Waste Matter in Pores," pp. 56-61; "Veneers," pp. 189-197.

A. B. Pattou and C. L. Vaughn, *Furniture, Furniture-Finishing, Decoration, and Patching,* pp. 402-3.

W. K. Schmidt, Furniture Manufacturer Magazine, Vol. 26, No. 6, p. 270, Dec., 1923, "Better Wood Surfaces" (On machine-sanding).

W. K. Schmidt, Furniture Manufacturer Magazine, Vol. 24, No. 5, p. 202, November, 1922.

W. K. Schmidt, *Problems of the Finishing-Room,* "Sanding and Sponging, and Importance of Good Sanding," Chapters V and VI, pp. 41-53; "Sanding Off Fuzz," Chapter XV, p. 104.

F. N. Vanderwalker, *Wood-Finishing, Plain and Decorative,* pp. 200-3.

CHAPTER III

WOOD-STAINS AND WATER-STAINING

13. Reasons for Staining.—1. Color harmony of the woodwork with the furnishings of a home requires staining, for wood in its natural tones does not usually harmonize with textiles and wall colors. Changing a garish, unpleasant color to a softer more attractive one that will take a place in a color scheme is an important reason for staining.

2. Greater beauty in a particular article can often be secured by staining. This can sometimes be obtained by changing an inferior or cheap wood to make it look like an expensive, beautiful one, such as imitation mahogany finish on birch thru staining; or, the coloring may bring out unsuspected qualities and beauty in the wood itself, by accentuating contrasts and bringing before the eye attractive natural characteristics which are not emphasized in the unstained material. The reaction of the stain upon flakes or cells of the medullary rays, its effect upon the mass of wood fibers, and its greater absorption by the open pores or broken cell cavities, are all elements of great surprise that are very interesting and vary with different kinds of wood.

3. Staining often tones down natural wood colors that are displeasing to the eye. Sometimes only part of a board needs to be changed in color, as in staining a streak or edge of sapwood to match the general color of the rest of the wood.

4. Sometimes staining is resorted to as a means of giving new wood an aged effect, as in weathered oak.

5. Greater durability can be obtained, where wood is exposed to the weather, thru preservative stains[1] made with creosote oil. No other finish is applied over creosote-stains. Oil-stains, if they contain certain quantities of drying-oils

---

[1] A. C. Newell, *Wood and Lumber*, Chapter XIV, "Wood Preservation," pp. 161-164.

such as linseed-oil, will protect or preserve wood thru the varnishlike film which is left as a covering after the oil has dried.

14. Definition of Wood-Staining.—Wood-finishers are beginning to give a very definite and narrow meaning to the word staining, and, at present, generally exclude all materials that add an opaque pigment to the surface, calling such coatings, which remain largely or partly upon or outside the surface, paints, lacquers, or enamels. With this exclusion in mind, staining is a changing of hue or tone which is due to a chemical reaction or to the application of a liquid that enters to some extent into the interior, and with coloring-matter changes the color of a layer of wood near the surface while still allowing the grain with its different cell arrangements to be seen clearly. Staining should leave a transparent effect instead of obscuring the surface with opaque material such as pigments. The coloring-matter in stains should be in a thoroly-dissolved condition, instead of being in a turbid muddy paste, when it is applied to the wood.

15. Classification of Wood-Stains.—So many kinds of stains are used for wood that any intelligent and useful classification of them is difficult. The problems which are apt to be met in applying a stain depend to a very large extent upon the solvent which is used to dissolve the coloring-matter. For this reason stains are generally classified according to the solvents used in making them.

The four classes of stains for wood are:

1. Water-stains.
2. Oil-stains.
3. Spirit-stains.
4. Chemical stains.

Two other classes of so-called stains are found on the market, known as varnish-stains and wax-stains. These are not transparent stains, as they obscure the grain and leave a layer of pigment on the surface. Wax-stains and varnish-stains are really in a class midway between true stains and enamels or paints. They are not often used in furniture-making, but are occasionally suitable for a home-repair job where the transparency of the grain of the wood is not considered. Colored varnishes are not popular with expert wood-finishers because they always leave muddy, unattractive effects.

The four classes of stain—water, oil, spirit, and chemical—may be subdivided generally into two classes, acid and alkaline, depending upon their chemical reaction with other substances.

Water-soluble acid-stains are very often made of coal-tar dyes, which dissolve in water, and can be used in an acid bath; or they may be produced from some of the weak acids, such as tannic or pyrogallic, which give little color unless used in connection with an alkali. Chromic acid which comes in red crystals was formerly used; but on account of its corrosive action, its expense, and uncertain effects, it has largely been replaced by its well-known salt, bichromate of potash. Picric acid which produces a good yellow on wood is also sometimes used with a water-soluble nigrosine to produce an olive-black tone known as Early English. The strong acids are little used by the wood-finisher.

Alkaline stains which were quite commonly used a few years ago were frequently preceded or followed by an acid treatment. A volatile alkali, such as ammonia, or some fixed alkali, like caustic soda, caustic potash, or bichromate of potash, when used alone or in mixtures where practicable, was generally the alkaline element employed in producing the so-called alkaline stains.

16. Water-Stains.—Many up-to-date wood-finishers consider coloring-matter dissolved in water as in many respects the most satisfactory stain to use on wood. Water passes easily from cell to cell[2] in the growing tree. Wood that has become thoroly dry will quickly reabsorb moisture;[3]

---

[2] A. C. Newell, *Wood and Lumber*, "Sap Movement and Food of a Tree," pp. 19-22.

[3] Ibid., "Amount of Swelling of Wood," pp. 131, 132.

and, if used in a wet place, it will take up water until its cell walls are at the saturation point; then, with still more moisture, it will become water-soaked as the cell lumina or cavities are gradually filled. This great readiness with which wood absorbs water is very important in wood-finishing, and is one reason for the great popularity of water-stains.

Stain-powder for mixing with water can now be secured in practically any shade of color desired for making water-stains.

Formerly, the colors used in mixing water-stains were fugitive, and the stains faded; but, at present, water-stains made from acid coal-tar dyes are much more permanent than spirit-stains or water-stains made from basic dyes, and also more permanent than oil-soluble dyes. Quite permanent acid coal-tar dyes are at present used almost exclusively in making water-stains. Vegetable extracts[4] are still made to some extent from various color-giving woods such as fustic, logwood, Brazilwood, and more recently from the osage orange. The ground-up barks from camwood and ground red sanders are also quoted on the market, and are usually cheaper than the other dyewoods. Very recently a water-soluble mineral water-stain, that seems to be very permanent to light and does not oxidize on exposure, has appeared on the market. It is called *Dakalite*, deriving part of its name from North Dakota, where it is found, and the other portion from the word lignite because it is extracted in manufacture from slacked or weathered lignite coal. Several of the colors that are most used for furniture-finishing are now sold commercially,[5] and these stains can be changed in color by mixing with acid coal-tar dyes to secure almost any shade or effect desired.

17. Advantages of Water-Stains.—The principal advantages of water-stains may be enumerated and discussed briefly, as follows:

---

[4] A. C. Newell, *Wood and Lumber*, "Gums, Chemicals, and Dyes, in Heart-Wood," pp. 59, 60.

[5] Manufactured by the Dakalite Products Co., Inc., Minot, North Dakota, and 13000 Athens Ave., Cleveland, Ohio.

1. Water-stains penetrate much more deeply into the wood than do either oil- or spirit-stains. The preliminary treatment for water-staining is sponging and resanding. Sponging opens up the fibers of the wood, and sanding removes the broken fragments of cell walls that have become matted into the cell cavities thru scraping and sanding. Water-stains enter very easily[6] into the open pores of wood that has been sponged and resanded. Wood substance also seems to be more permeable to water than to other solvents used in making stains.

2. Water-stain powders are very soluble, especially in hot water. They generally are moderately soluble in cold water, but for deeper colors hot water is preferable. Some water-stains are improved by straining thru filter-paper or cloth having a fine mesh.

3. The dipping process can be used safely with water-stains, whereas dipping in a spirit- or oil-stain is dangerous, and greatly increases the fire risk of a building. Many furniture factories have large vats filled with water-stains. Chairs, tables, and other articles are completely immersed in the liquid for a short time, and then removed and wiped in order to secure as even a tone as possible.

4. It is very easy to secure darker or lighter shades and tints with water-stains. For a lighter tone all that is necessary is to dilute the stain with water. For darker shades more powder may be added to the stain. In case additional powder will not dissolve, one or more coats of stain may be put over the first attempt at staining, each application making a darker effect or tone. It is possible to secure very dark or deep effects with water-stains.

5. The color of a water-stained article can be changed to a large extent by applying a coat of a different color over a stain that is not suitable or which does not match the required color. Mottled effects or uneven tones of the same color, can be produced by adding color with a brush before the first coat is absolutely dry. A similar effect can usually

---

[6] A. C. Newell, *Wood and Lumber*, "Wood Substance Absorbs Moisture," p. 112.

be produced by wetting a water-stained surface with a brush or sponge and then applying more color before the dampened surface dries out.

6. It is possible and safe to apply water-stains hot, thus securing greater penetration.

7. The greatest possible variety in colors, shades, and tints is obtainable in water colors since the advent of water-soluble coal-tar dyes. Fewer colors, and less delicate hues, are obtainable in oil- and spirit- than in water-stains.

8. Permanency, at least equal to that of other stains, is now secured with Dakalite and coal-tar water-stains. Some authorities state positively that coal-tar water-soluble stains are more permanent than oil-soluble colors of similar origin.[7] A large proportion of all the stains used for wood is now made from aniline and non-aniline dyes which are coal-tar products. The dye manufactures recommend acid colors that are water-soluble coal-tar dyes for use in wood-staining, as they are far more permanent in light than are basic colors which are frequently very brilliant but, unfortunately, quite fugitive.

9. More transparent, clear effects can be secured with water-stains than with any other kind, with the exception of some of the chemical stains, and possibly a few of the volatile oil-stains. When water-stains are used, no visible pigments remain on the surface of the wood to obscure and spoil the beauty of the grain. Clear, brilliant effects can be obtained with water-stains which penetrate into the wood fibers and change the color of the wood to an appreciable depth.

10. Brushes are much more easily cleaned and taken care of when water-stain is used, because they can be washed out in water; while brushes used in oil- or spirit-stains require cleaning in turpentine or alcohol, a more difficult and slower process.

11. In general, water-stains are cheaper, gallon for gallon, than any other kind; because the solvent, water, costs

---

[7] See Section 27, "Volatile Oil-Stains," p. 55.

less than turpentine, alcohol, and other solvents used to dissolve oil- and spirit-stains.

12. Water-stains dry quickly.

13. Water-stains will usually penetrate thru one coat of linseed oil, or will even darken a filled surface to some extent. The grain is not usually raised appreciably when water-stains are applied to surfaces that have already been oiled or filled. Much less water-stain is absorbed by the wood, however, under such conditions.

18. Disadvantages of Water-Stains.—The chief disadvantages of water-stains are:

1. The use of water-stains requires sponging and resanding[8] as a preliminary preparation in order to avoid the fuzziness that would appear on the surface of the wood without this treatment, Fig. 6. The extra expense resulting from the sponging and resanding operations adds to the labor cost. Sandpapering cannot be done over a water-stained surface without great danger of cutting thru the stained layer, leaving streaks or spots of the natural color of the wood which show in a very objectionable manner. If there is fuzz on a water-stained surface it is best to apply a wash of shellac, using liquid shellac diluted with about seven parts of alcohol. Sanding can be done more easily, and with less danger, over a coat of thin shellac; but fine sandpaper (3/0 or 4/0) should be used, and great care must be taken to avoid cutting thru the stain at the corners and other exposed places.

The proper procedure is to sponge, allow to dry, and then resand, whenever water-stains are to be applied. If this method is followed little or no sanding will be necessary after staining with water-stains.

2. The use of water in sponging and in the staining process may have a tendency to loosen glued joints. This difficulty can usually be overcome if care is taken to avoid long immersion while dipping, and also thru prompt wiping to prevent too great absorption, if the water-stain is applied

---

[8] See Section 11, "Sponging and Resanding," p. 33.

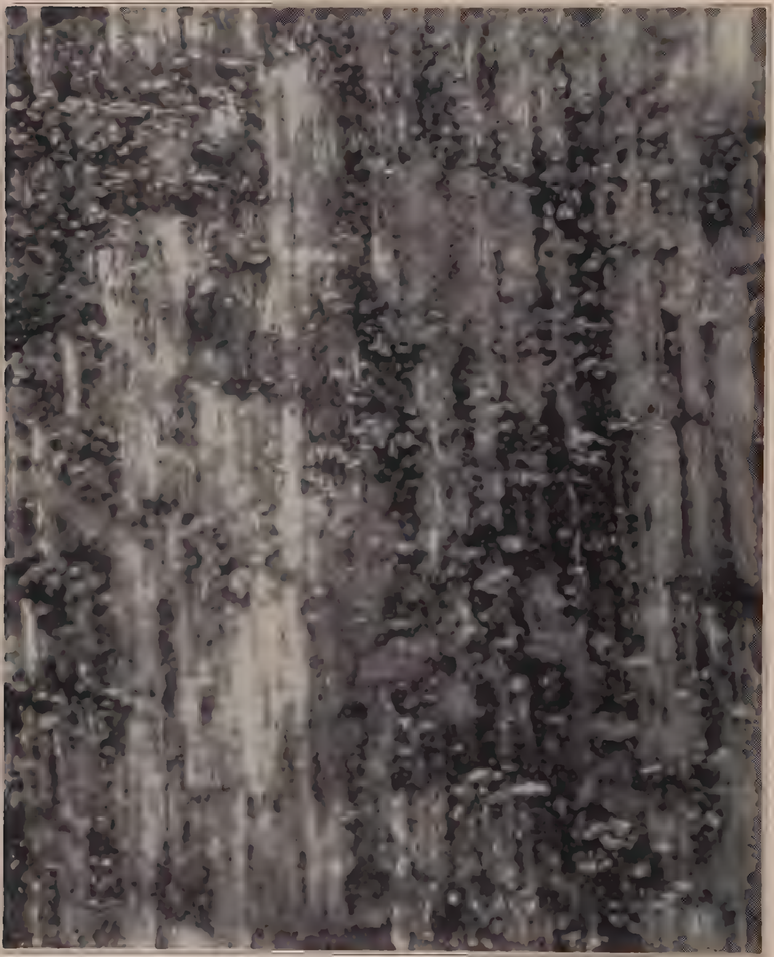


Fig. 6—Fuzz on the Surface of a Cypress Board

This photomicrograph shows fuzz on the surface of a cypress board after paste wood-filler had been applied and rubbed off. Water used in sponging raises the grain or fuzz much more than oil-stains and wood-fillers do.

with a brush. The greatest danger comes from using water-stains on thin veneers which may loosen at the joints.

3. It is difficult to apply water-stains with a brush and secure an even tone on a large surface. More care and skill are needed in brushing on water-stains than is the case with oil-stains. Water-stains dry rapidly, and unless a rather wet brush, full of stain, is used the edge of one brush-stroke of stain may dry before the next is put on adjacent to it. The brush-strokes should be made lengthwise of the grain wherever possible. The use of a brush that has little stain in it is to be avoided. To dip the brush in the stain very often, and always before it begins to dry, is a good rule.

A large surface may be tipped slightly. In this case, if one begins at the back of the surface, which should be highest up, and brushes the stain on crosswise, the excess of liquid will run to the lower edge of the brush-stroke and keep it wet until the next application of stain is made. Streaks and laps can usually be avoided entirely by this method, if the workman applies the stain rapidly.

Another method of avoiding laps is to sponge the article with water and apply the stain to the damp surface. The color is likely to be slightly lighter when the last method is used; but stronger stain can be used safely, or a second application of the coloring liquid can be made after the first coat has dried.

4. Water-stains of the most permanent character, made from coal-tar dyes, frequently have an acid reaction, and therefore should be kept in glass or earthenware containers when in a liquid form. Brushes with hard-rubber ferrules are best because metal bindings on brushes may be affected by acids.

5. Sap-wood streaks[9] are apt to take up too much stain; and, on some of the lighter kinds of wood, they may become darker than the heart-wood. This trouble can largely be avoided by sponging the sap-wood with water, thus weaken-

---

[9] A. C. Newell, *Wood and Lumber*, "Sap-Wood," p. 54.

ing the absorptive power of that part of the wood; the stain is then quickly applied evenly over the whole surface. Another method is to use weaker stain on sap-wood, which absorbs more color than the rest of the wood and thus becomes too dark.

Woods with strong contrast between the sap-wood and heart-wood, or kinds that are not very porous, usually require an entirely different treatment. In such cases the sap-wood requires more stain than the remainder of the wood. A coat of stain is applied to the light streaks, and after it dries the entire surface may be stained. Stain may also be put on the sap-streaks after the object has been stained as a whole. Blending, by dampening the line at the edge of the sap-wood, is often helpful in securing a soft lap.

19. Helpful Hints on Water-Staining. — 1. End-grain takes too much stain, consequently it becomes too dark unless care is taken to prevent this extra absorption. The open ends of the tracheal vessels,[10] or the tracheids in some woods, absorb very avidly water and stains in general. Sometimes sponging the end-grain, and applying the stain while this part of the wood is wet, will even up the color as it may do on sap-wood. Some wood-finishers prefer to apply a coat of very thin glue sizing to the end-grain and sap-wood, after experiments are made to determine the proportions of sizing glue and water which are needed in the mixture. End-grain usually requires more glue in the sizing mixture than does sap-wood. The stain should not be applied until the sizing has dried in the pores of the wood and resanding has been done where necessary.

Knots and different kinds of wood which are laid side by side sometimes require special treatment, but some variation of the methods suggested for end-grain and sap-wood are ordinarily used.

The end-grain of woods with large open pores especially is sometimes treated with a coat of paste wood-filler to prevent the stain from soaking in too much. None of the filler should run over on the faces and edges, or lighter spots or streaks will show where they are not wanted.

---

[10] A. C. Newell, *Wood and Lumber*, "Tracheal Vessels and Tracheids," pp. 34-36.

2. Brushes should not be kept standing in water-stains, because soaking will cause the bristles to become too soft and "moppy" for good work. They can be washed in water and dried, and thus kept in better condition for future work. A fitch-brush about 2½″ wide, set with a rubber ferrule, is frequently used. Polar-bear bristles, which should be rubber-set, are also preferred for some kinds of work. A rather soft brush will do good work in staining a close-grained wood; but, for wood with large open pores, a stiff bristle-brush is superior as the bottoms of the cell-openings are reached and covered to better advantage. Stiff brushes give a flatter or evener tone than flaccid brushes in staining a porous wood.

A soft brush, if used on wood with large open pores, leaves light specks in the cell cavities because stain thus applied does not penetrate sufficiently into the tiny openings. Glue-set brushes cannot be used for any length of time in water-stains, because the bristles will come out. Either oval or flat brushes are satisfactory, but in any case a rather large size is preferable. On large work a 3″ or 4″ brush should be used, as it holds more stain.

3. Brushes used in applying water-stains should be kept quite wet or full of stain, because dry brushes are apt to cause streaks, laps, and an uneven tone. Too wet a brush, which is dripping with stain, will bring trouble thru drops falling where stain is not wanted at that time. After dipping the brush into stain, it is best to get rid of any excess wetness by wiping one side of the bristles against the rim of the container, or on a drip-wire placed across the top for that purpose.

4. Work should be done rapidly and with great care that stain may not run over the edges or drop on surfaces which are to be stained later on. Careless work is apt to leave spots that will show after the staining operation is completed. The workman should also be very careful as to

where he places the stain container, if he would avoid spots where they are not wanted.

5. The proper places for beginning and ending, when applying water-stain to an article of furniture, are worth consideration before work is begun. The most important surfaces should always be stained last, if possible. The parts to stain first are the bottom, back, or under portions which are less seen than the front or top of most articles.

6. Hot water-stains penetrate deeper and dry faster, both when the dipping process is used and when the stain is applied with a brush.

7. When the dipping process is used the article should remain completely immersed only a moment; then it should be withdrawn quickly, and after standing on the dripping-board for a few moments for the excess stain to run off, the entire piece should be wiped to even the depth of the stain.

8. Veneers are quite apt to appear lighter than solid wood after staining. Usually, a thin stain applied as a second coat to the veneer only will even up the color. Veneer is very thin;[11] and the glue which is used in gluing it to its place may, to a slight extent, size the surface thus leaving its penetrability reduced more or less.

9. Greater evenness of tone can be secured in using water-stains by applying two or three coats of thin stain than by the use of one application of strong color. The second coat lessens any defects of the first, to some extent, and laps or streaks are much fainter than when strong stain is used.

---

[11] A. C. Newell, *Wood and Lumber*, "Veneers and Plywood," pp. 189-197.

REFERENCES—CHAPTER III

WOOD-STAINS AND WATER-STAINING

Grand Rapids Wood-Finishing Company, *Better Wood-Finishing,* Chapters I and II.

H. R. Jeffrey, *Wood-Finishing,* Chapter II, pp. 16-26.

A. A. Kelly, *Expert Wood-Finisher,* "Water-Staining," pp. 90-99; "Bleaching," p. 93; "Raising the Grain," p. 94; "Deepening the Color," p. 95.

F. Maire, *The Modern Wood-Finisher,* "Stains and Staining," pp. 46-55.

R. A. McGee and A. G. Brown, *Instruction Units in Wood-Finishing,* pp. 13-14.

A. C. Newell, *Wood and Lumber,* "Preservatives and Wood-Finishing," pp. 163-4; also Sections 10, 15, 22, 29, 46, 55, 60, 102.

G. M. Nyman, Industrial-Arts Magazine, Vol. XII, No. 6, p. 232, June, 1923.

A. B. Pattou and C. L. Vaughn, *Furniture, Furniture-Finishing, Decoration, and Patching,* pp. 167-171.

W. K. Schmidt, Furniture Manufacturer Magazine, "Staining Work," Vol. 24, No. 6, p. 255, Dec., 1922.

W. K. Schmidt, *Problems of the Finishing-Room,* Chapters VII, VIII, IX, X, XVI, XXVII, XXXVI, XXXVII.

F. N. Vanderwalker, *Wood-Finishing, Plain and Decorative,* pp. 32-66, 85-91.

21024

CHAPTER IV

Oil-Stains

20. Three Kinds of Stain.—There are several kinds of oil-stain on the market, each of which is intended for a distinct purpose, and should not be confused with the others. The most distinctive types are:

1. *Pigment-stains,* which are mixed with a drying-oil, and are usually thinned with a solvent such as turpentine.
2. *Preservative-stains,* which contain pigments, and creosote, which is not a drying-oil. Frequently linseed-oil, and sometimes turpentine, heavy benzine, or benzine Japan drier are added to the mixture.
3. *Volatile oil-stains,* often called penetrating stains, which are usually made from oil-soluble coal-tar colors dissolved in a solvent such as turpentine, solvent naphtha, benzene, or benzol.

21. Pigment Oil-Stains.—Colors or pigments which are ground in raw linseed-oil were formerly much used as stains. They can be thinned with turpentine, or a mixture of turpentine and linseed-oil, or even with benzine with a little Japan drier and painted on wood with a brush. After soaking into the wood fibers for a few minutes, such stains should be wiped off and allowed to dry for several days before any other finishing is attempted. Vandyke brown, burnt and raw sienna, the umbers, ultramarine blue, and yellow ochre are examples of colors ground in oil that can be purchased at any paint-shop.

Asphaltum black, which is an asphaltum varnish, is another material that can be thinned with turpentine and used as an oil-stain. It is very permanent when exposed to light and is especially good as a stain for finishing cypress, as it produces a dark brown tone similar to mission-oak in color.

Dry pigment-colors do not dissolve well in turpentine, and are not as satisfactory when used as stains as are colors which are ground in oil.

Colors which are ground in oil are chiefly used at the present time as coloring-matter to mix with paints and are entirely suitable for that use. They produce more brilliant effects in paint than do dry pigment-colors, and keep the mixture more liquid so that it will spread better with a brush.

When dark pigment-colors are used with oil as a stain they have a covering effect instead of the pleasing transparency of water colors. These somewhat opaque results are just what are desired for silver gray or Jacobean stains, but are not pleasing for staining in general.

22. Preparation of Pigment Oil-Stains.—The various pigments ground in oil which are obtainable on the market are not all equally permanent when exposed to light. If one has the three primary colors—red, yellow, and blue—and black, nearly any desired tone or hue can be secured if he knows how to mix colors. The following are among the most permanent of the colors that are ground in oil:

Pigments Permanent in Light

Ivory Black
Vandyke Brown
Burnt Ochre
Yellow Ochre
French Yellow Ochre
Venetian Red
Indian Red
Light Red
Madder Lake Red
Burnt Sienna
Raw Sienna
Burnt Umber
Raw Umber
Ultramarine

The above colors are not all equal in chroma or brilliance of hue, some of them being weak in coloring power. A pigment which is low in chroma must be used in a greater amount than is the case where the color is strong and brilliant. On account of the variations in strength of various colors the amount by weight that is required to produce desired tones also varies. The following formula is suggestive of the approximate composition of a pigment oil-stain for use on the trim or woodwork of a house or in staining furniture:

To each gallon:
70 per cent raw linseed-oil ✓
20 per cent turpentine
10 per cent Japan drier
1 to 2½ pounds of pigment-colors finely ground in oil

A stain with such a large per cent of raw linseed-oil dries rather slowly even with a drier to quicken the oxidation process. A much quicker drying stain can be made by using boiled instead of raw linseed-oil. The following formula makes a rather quick-drying stain that is somewhat thinner than the above mixture and will penetrate deeper into the wood:

To each gallon:
1 part boiled linseed-oil ✓
2 parts turpentine
1 to 2½ pounds of pigment-colors ground in oil

23. Advantages of Pigment Oil-Stains:—

1. They are easily prepared.

2. They are very easy to apply, even by children.

3. They do not raise the grain, consequently sponging and resanding are unnecessary, and two operations are saved.

4. They may be used on thin veneers without danger of loosening the glue.

5. They are cheaper to apply than water-stains, consequently they are used on cheap furniture, and frequently in house-finishing.

6. They are good to use on the interior of case-goods where raising the grain and resanding are difficult.

7. They generally contain a certain amount of some drying-oil, such as linseed-oil, and in drying leave a thin varnish-like film which protects the wood to some extent.

8. A drying-oil, such as linseed-oil, unless it is bleached, darkens the wood even without being mixed with any colors.

9. Oil-colors can be mixed with wood-filler, and this combination stains and fills in one operation.

10. Oil-stains can be used successfully on certain very absorptive woods, such as cypress which becomes very rough and porous when water-staining is attempted.

11. Stains containing a drying-oil, such as linseed-oil, do not penetrate as deeply into the wood as they do when turpentine is used. Stains with drying-oils as the vehicle give an even, flat tone, however, because they do not penetrate unevenly in spots on account of irregular wavy or end-grain around or near knots.

12. Attractive effects can be produced with several of the pigment oil-stains on some of the close-grained woods, such as poplar, cherry, maple, white pine, and even on walnut which is somewhat porous.

24. Disadvantages of Pigment Oil-Stains:—

1. Oil-stains do not penetrate deeply, and as a result they are easily cut thru by sandpaper, or are quickly worn off by use.

2. Restaining is difficult with oil-stains, therefore the proper color must be secured with one coat. (If the stain is raised with benzene, another darker color can be applied with some success.)

3. Oil-stain pigments are opaque and remain on the surface to some extent; they obscure the grain and cause a loss of transparency.

4. Oil-stains are more expensive than water-stains, and do not cover as much surface gallon for gallon.

5. If it is applied too slowly, or if it is not rubbed soon enough, an oil-stain may go into the pores too deeply to dry promptly; and, later on, it may ooze out and cause trouble.

6. Oil-stains require several days for proper drying.

7. Oil-stains are likely to ‘‘lift’’ or come off to some extent with a filler.

8. The shades of color available in pigment oil-stains are more limited in number than in water-stains.

25. Use of Pigment Oil-Stains.—The use of pigment oil-stains for coloring the wood of furniture has diminished during recent years because better water-stains have been placed on the market. Oil-stains are still in very general use for architectural work. It is easier to apply oil-stains than water-stains on wood used for the inside finish or trimming of a house, especially if the wood is nailed in place before the stain is applied. Whenever it is difficult to raise the grain of wood and resand in order to remove the fuzz caused by sponging, it is usually best to color the wood with an oil-stain rather than with water-stain.

Oil-stains can be applied with a brush without danger from too rapid drying which causes laps and streaks. In order to obtain a sufficient depth of penetration of the coloring-matter it is necessary to allow oil-stains to remain on the surface, and to apply a coat thick enough so that the stained liquid can soak into the pores of the wood. The excess remaining on the surface after a few minutes should be wiped off, or all transparency may be lost, and the effect will be much like that of a painted instead of a stained surface. Cotton-waste, old rags, or almost any absorbent material found in a finishing-room, may be used for wiping.

26. Creosote Oil-Stains.—Stains for use out-of-doors are frequently made with one of the creosote-oils as a vehicle for carrying the coloring-matter to the wood.[1] Shingle-stains which are made from coal-tar creosote, or water-gas-tar creosote, together with colors are in common use. The shingles are usually dipped for a few minutes, then stood on a draining-board to dry. Such creosote oil-stains are frequently put on for a one-coat finish. Paints and varnishes do not usually adhere properly over creosote-oil.[2]

Creosote oil-stains can be used best in warm weather. In cold seasons certain so-called ''creosote-salts'' are likely to settle, leaving part of the stain in a condition that cannot be used.

Creosote-oil is an excellent preservative of wood from decay fungi, therefore it is valuable for outside use. A

---

1. A. C. Newell, *Wood and Lumber*, "Creosote Oils," pp. 161, 162.
2. Ibid., "Preservatives and Wood-Finishing," pp. 163, 164.

preservative-oil is not really needed for furniture or for the inside finish of a house where the wood is not exposed to dampness. Creosote-oil, when used in stains for articles requiring several coats of finish, is harmful when applied to furniture, on account of its dark color, lack of rapid evaporation, and tendency to prevent other finishes from adhering properly.

The pigments commonly used in creosote shingle-stains are chrome green, and the red and brown iron oxides.

A creosote shingle-stain[3] might contain about 1½ pounds of pigment to the gallon, and a vehicle and solvent consisting of 2 parts of creosote-oil, 2 parts of heavy benzene, and 1 part of benzene Japan drier.

27. Volatile Oil-Stains.—The market has at present a comparatively new type of so-called oil-stains which are largely made from coal-tar dye powders dissolved in volatile oils, such as turpentine, benzol, light and heavy naphthas, and various turpentine substitutes mostly of a mineral nature. These stains, called penetrating-stains, are put up in both dry and liquid form and are quite popular at present, because they penetrate deeply into the wood and do not require the preliminary treatments of raising the grain and resanding that are so necessary with water-stains; also, because the aniline and other coal-tar dye powders are more soluble than pigment colors, and do not obscure the grain as such colors mixed with drying-oils always do to some extent.

Volatile oil-stains are made in quite a variety of colors especially for use on oak, walnut, and mahogany. They should usually be wiped before they dry in order to produce an even tone, and must be handled with more speed and care than is necessary with ordinary pigment-stains, because the solvents used evaporate more rapidly than do the drying-oils, such as linseed-oil, used with pigment-stains or colors ground in oil. Volatile oil-stains are really in a class by themselves, because they have many of the advantages of pigment oil-stains and not many of the disadvantages.

---

[3] U. S. Bureau of Standards, Circular No. 69, *Paints and Varnishes*, pp. 53, 54.

Volatile oil-stains sold in a liquid form are apt to contain benzol,[4] at least in part, as a solvent. Benzol and coal-tar dyes are coal-tar products; and, being of a somewhat similar nature chemically, the liquid seems to be an excellent solvent of the powders. Benzol alone is recommended by some manufacturers as a solvent for some of their oil-soluble colors.

Many oil-soluble aniline and other coal-tar dry powders sold for oil-stains are preferably dissolved in turpentine; in fact, the manufacturers recommend this solvent. Turpentine substitutes, especially if they contain benzol, can usually be used successfully instead of turpentine. Benzene or benzol, naphtha, gasoline, kerosene, and carbon tetrachloride, are sometimes used as solvents for oil-soluble coal-tar dyes.

28. Permanency of Oil-Soluble Coal Tar Stains.—It is said by some dealers in wood-stains that aniline and other coal-tar oil- and spirit-stains fade more than water-soluble coal-tar dyes do. This statement is especially true, as far as spirit-stains are concerned, because they are made of fugitive basic dyes, which manufacturers and chemists admit are not fast to light and permanent, tho brilliant when first used. Oil-soluble coal-tar dyes now being made are often more permanent than basic dyes which are used for spirit-stains, and are recommended for use on wood by some reliable manufacturers. These oil-stains are used quite extensively, and are proving to be fairly satisfactory; but experts say that they do not possess a fastness to light equal to that usual with water-soluble acid coal-tar dyes.

29. Shellac-Wash over Volatile Oil-Stains.—Lifting of the stain by after treatments of filler or shellac is a common fault of volatile oil- and spirit-stains. Volatile oil-stains are not much changed by a filler, however, if a thin coat of shellac, mixed in the proportion of one part of liquid shellac to seven or eight parts of alcohol, is applied over the stain and allowed to dry before filling. Shellac in its full strength from the can should not be used on porous woods that require a filler until after the filling is finished. A very thin shellac coat, called a shellac-wash, may be used over a stain without filling the pores to such an extent that a filler will not have proper anchorage to hold it in place.

---

[4] W. K. Schmidt. *Problems of the Finishing-Room,* Chapter XLII, "Benzols," p. 231.

Varnishes cannot be applied directly over any of the oil-stains without probable loss in clearness of tone, because the solvents used in all cases are the same or similar, and some of the coloring-matter may be "lifted" and mix with the varnish-coat, thus producing a muddy or cloudy effect, and a loss of transparency.

Volatile oil-stains, especially those containing benzol as a solvent, penetrate very deeply into the wood in comparison to pigment oil-stains, and do not dry as readily as is indicated by appearances on the outside. It is best to allow at least 24 hours for drying before a shellac-wash is applied over a volatile oil-stain.

Sometimes, in order to secure certain tone or color effects, the shellac-wash is omitted between the coats of stain and filler. In all cases, in order to prevent "bleeding" of the coal-tar oil-stains into the varnish-coats, it is important that one or more coats of shellac be applied to the stained or stained and filled wood before any varnishing is done.

REFERENCES—CHAPTER IV

OIL-STAINS

Bureau of Standards, Circular No. 69, *Paint and Varnish,* "Mixing Stains," pp. 51-56.

Grand Rapids Wood-Finishing Co., *"Permanence of Aniline Dyes,"* Bulletin B.

H. R. Jeffrey, *Wood-Finishing,* Part of Chapter II, "Staining," pp. 28-9.

A. A. Kelly, *The Expert House-Painter,* "Creosote-Stains," pp. 81-86; "Description of Stains and Their Uses," pp. 118-127.

A. A. Kelly, *The Expert Wood-Finisher,* Part of Chapter on "Wood-Stains and Wood-Staining," pp. 90-111; "Oil-Soluble Stain," pp. 118-121.

R. A. McGee and A. G. Brown, *Instruction Units in Wood-Finishing,* pp. 10-13.

F. Maire, *The Modern Wood-Finisher,* Chapter VI, "Stains and Staining," pp. 46-55.

A. C. Newell, *Wood and Lumber,* "Creosote-Oils," pp. 161-2.

G. M. Nyman, Industrial-Arts Magazine, Vol. XII, No. 6, p. 232, June, 1923.

W. K. Schmidt, *Problems of the Finishing-Room,* Chapters 8, 11, 28, 62, 69; and "Stain-Formulas," p. 377.

F. N. Vanderwalker, *Wood-Finishing, Plain and Decorative,* Chapter IX, pp. 33, 36, 98-112; "Formulas for Oil-Stains," pp. 104-12.

CHAPTER V

SPIRIT-STAINS AND APPLYING STAINS

30. Characteristics of Spirit-Stains.—A number of years ago a few firms put lines of spirit-stains on the market, manufactured from various colors that are soluble in alcohol. At the present time the colors or dyes which are used are almost entirely spirit-soluble basic coal-tar dyes.

Spirit-stains dry very, very quickly, and do not penetrate deeply into the wood. It has been found that pure spirit-stains dry with such great rapidity that it is difficult to apply them evenly. Laps, streaks, and brush-marks are likely to disfigure any large surface stained with spirit-stain. The trouble is due entirely to the rapid evaporation of the alcohol which is used as the solvent for the colors.

Spirit-stains are more expensive than water-stains, because the solvent, alcohol, costs much more than water.

Spirit-stains are sometimes used for quick work, especially for touching up spots and streaks, and in making repairs or renewing old finishes. The expert can occasionally use them to advantage, but the beginner always has trouble with them.

Another difficulty with spirit-stains is that they may "lift" with the filler-coat, or with the application of shellac which is a spirit-varnish cut with alcohol. Such stains are liable to mix with the shellac under the brush, and produce a muddy effect which spoils the transparency and beauty of the finish.

31. Mixed Spirit-Stains and Volatile Oil-Stains.—Some manufacturers of spirit-stains have changed their formulas, and do not use alcohol exclusively as a solvent. Turpentine and benzol are sometimes used as solvents or thinners in addition to alcohol, and these oils slow down the rapidity of drying of the spirit-stain. Benzol also causes the stain to penetrate more deeply than if alcohol alone is used. These stains can be thinned with either alcohol or turpentine, but turpentine is preferable on account of its slower evaporation.

Some of the best liquid stains on the market today are really a combination of volatile oil- and spirit-stains, and these mixtures are giving very satisfactory results tho they are rather expensive on account of the high cost of the solvents. Water is also sometimes used as a thinner for spirit-stains, reducing the rapidity of drying to some extent.

32. Evaporation and Fire-Risk.—Spirit-stains cannot be left in open vats in factories on account of the rapid evaporation of the solvents used, and because this practice would increase the fire-risk. Such stains should be kept in tightly-closed glass bottles, if possible.

33. Method of Application.—More even tones and brilliant effects can usually be obtained from spirit-stains by wiping and spreading any excess of color soon after the dye is applied with a brush. The best results are usually secured (1) by working rapidly with a brush loaded with color, rather than with an almost dry brush; and (2) by evening up, by wiping before the stain has set or dried.

34. Spirit-Stains Fade.—Spirit-stains made from aniline or other coal-tar dyes are considered by many experts to be the most fugitive of all stains, altho they are much more permanent than they were a few years ago. Their tendency to fade, and difficulty in application, have caused them to be used much less than are either water- or oil-stains. Spirit-stains are made from basic coal-tar dyes which the manufacturers know to be fugitive. Where a temporary brilliant effect is desired, and fastness to light is not a requisite, such stains may be used to advantage. Whenever spirit-stains are used on articles of furniture the fresh colors should not be exposed to bright light until after coats of shellac and varnish have been applied. Such impervious finishes keep out the air and prevent fading to a large extent.

APPLYING STAINS[1]

35. Procedure in Staining.—The inexperienced writer of stories has difficulty in deciding on "how to start" or "where to start" the writing. The novice in wood-finishing has similar problems, and must decide which parts should be stained first. In general, it is best to begin with the most inconspicuous or least important parts, and to finish with the front, or parts that are most often seen. On vertical surfaces it is best to start at the top and work downward, usually with the grain. The article to be stained should be placed, whenever possible, so that no stain will drip or spatter onto an important surface, because spots will not always blend out. This trouble with spots may be serious, if the dye or color drips onto unstained portions of the article; and it is equally or more bothersome when drops fall upon surfaces already stained. Spots are not usually so troublesome with oil-stains as with other kinds.

Placing the surface in an inclined position, with the operator standing at the lower long edge, and brushing from left to right, or lengthwise of the grain of the wood, are frequently helpful in preventing streaks and laps. The brush for staining should, in general, be kept quite full of stain, but must not be wet enough to drip. Part of the liquid can be removed from the brush by wiping it on a wire strung across the can, or by using the side of the container itself to press out the excess of stain.

The inside and shelves of cases, backs of legs, under side of arms of chairs, and other parts that will be seen but little should be stained first.

36. Use of Brushes and Wiping.—The brushes must generally be handled with care to prevent the stain from running over edges, and to avoid the drying of portions of a surface before it is entirely covered. It is best to apply the stain lengthwise or with the grain of the wood rather than across the grain. A flatter, more even tone can be secured by brushing lengthwise, especially on open-grained or porous woods, because the bristles of the brush get down into the low places of the cell lumina or openings more satisfactorily when the stain is applied with the grain. Most stains must be rubbed or wiped off with some absorbent material, such as cotton-waste. It is often best to wipe off crosswise and to finish lengthwise. The crosswise wiping rubs the stain into the pores, and the lengthwise rubbing cleans off any excess and evens up the color.

---

[1] See also Section 18, "Disadvantages of Water-Stains," p. 43; Section 19, "Helpful Hints on Water-Staining," p. 46; Section 23, "Advantages of Pigment Oil-Stains," p. 52; Section 24, "Disadvantages of Pigment Oil-Stains," p. 53.

37. Speed in Staining.—Speed in applying the coloring-liquid is fundamental to success with most stains. Speed secures uniform color and helps in preventing laps and streaks. The amount of speed required varies with the kinds of stain used, depending upon the rapidity of the evaporation of the solvents which hold the coloring-matter in solution. Spirit-stains containing alcohol evaporate with astonishing rapidity. Volatile oil-stains vary greatly in rapidity of drying; those containing gasoline evaporate almost instantly; while, if turpentine is used as a solvent, vaporization is much slower.

The manufacturers of the best volatile oil-stains in liquid form ordinarily use solvents, generally in a mixture, which will control the rapidity of drying and slow down the evaporation to practical workable limits. Pigment oil-stains usually contain a certain amount of some drying-oil, usually raw linseed-oil, and this makes them dry slowly. There is no difficulty in applying pigment oil-stains, as they dry very slowly—so slowly in fact, that no other finish should be placed over them for several days.

REFERENCES—CHAPTER V

Spirit-Stains

H. R. Jeffrey, *Wood-Finishing,* Chapter II, "Staining," pp. 26-27.
A. A. Kelly, *The Expert Wood-Finisher,* "Wood-Stains and Wood Staining," p. 93.
W. K. Schmidt, *Problems of the Finishing-Room,* Chapters VIII and IX, pp. 61-69; also pp. 88, 226, 229.

Applying Stains

Grand Rapids Wood-Finishing Co., *Better Wood-Finishing,* Chapter IV.
H. R. Jeffrey, *Wood-Finishing,* Chapter II, pp. 25-29.
A. A. Kelly, *The Expert Wood-Finisher,* "Wood-Stains and Wood-Staining," p. 93.
W. K. Schmidt, *Problems of the Finishing-Room,* Chapters VII, X, XI, XII, XIII.

CHAPTER VI

Chemical Stains

During the years just preceding the world war certain forms of chemical stain enjoyed quite a little popularity. White oak was a suitable material for the manufacture of mission furniture which was then in vogue, and this wood with its high tannic-acid content lent itself admirably to several chemical stains, the most satisfactory of which was produced by the ammonia fuming process. Other acid and alkaline stains were used with some success, and writers of that period predicted a great future for chemical stains. The most popular stains of the present day are the result of chemical discoveries, but they are synthetic dyes instead of true chemical stains in the sense that that term is usually used by the wood-finisher.

38. Definition of Chemical Stains.—In a scientific sense, chemical stains depend upon some chemical reaction in the wood resulting in the formation of new colored compounds. One of the chemicals is sometimes contained in the wood itself. In other cases one chemical may be applied to the surface of the wood and be absorbed or produce some chemical change. Later on, another chemical which may be in the form of a gas or liquid, may come in contact with the first and bring about a chemical change in the wood itself, thereby causing a change in color. True chemical staining, therefore, is the result of chemical action in the wood which produces a new color. Often chemical staining depends upon the changing of coloring-matter already in the wood to a new or different color, because of a chemical reaction, rather than to the application of a dye or pigment. Woods differ greatly in their chemical composition, consequently they react very differently to chemical treatment.[1]

---

[1] A. C. Newell, *Wood and Lumber*, Chapter VI, especially the sections on "Cellulose," pp. 76-78; and "Tannins and Extracts of Wood," pp. 86-89.

39. Waning Popularity of Chemical Stains.—Oak, which a few years ago was so much used for furniture, has partly been replaced by black walnut and other woods which are not with our present knowledge so easily stained by chemical processes. Another reason for the decline of chemical staining is that a uniform tone cannot usually be secured on an article of furniture, even when made of oak which is one of the best woods for this kind of staining. This unevenness is due to the fact that sap-wood is not changed to a tone to match heart-wood, and boards from different trees do not take equal amounts of color.

Considerable "doctoring" of spots and streaks was a common aftermath of chemical staining. Some factories gradually came to the practice of giving a light chemical stain, following this treatment with a water-soluble or other coal-tar dye coating to even up the color and produce a flat uniform tone. The hardest blow of all to chemical stains has come from the great improvements in coal-tar dyes that are, in some of their forms, as permanent as any stains. These synthetic dyes are very convenient to use, and last, but not least, they can be found in almost any color, shade, and tint desired.

Much of the "period furniture" of the present day, which has to a considerable extent displaced the oak "mission furniture" of a few years ago, is made of black walnut; and this wood is finished in various ways, as in a natural color, given a light or weak stain, two-toned or duotoned with light and dark effects of the same color, or even polychromed in part, with the remainder left in a natural finish. Suitable chemical finishes for walnut are not common on the market. Staining chemicals can be used, however, to a limited extent for articles in "mission style," especially, when they are made of oak or chestnut and a few other woods. The recent wave of popularity shown by walnut has somewhat affected and reduced the use of mahogany which is in many respects the best of all woods for high-grade furniture. Chemical stains are not generally used on mahogany, which is left nearly in its natural color, or slightly toned with either red or brown water-soluble stains.

40. Chemicals Used in Staining.—Chemical stains are generally acid or alkaline in reaction. A combination of the two is usual in producing the colors that have been most popular recently.

Acid stains are very commonly dependent upon either tannic or pyrogallic acid as a base, especially where shades of brown are produced. Strong acids are not often used. Acetic acid has been tried, but its benefit is quite doubtful. Chromic acid and salts are useful in connection with alkalies and other stains, and emphasize or brighten the resultant colors. Picric acid is useful where a decided yellow is desired, and can be used in connection with acid water-soluble coal-tar colors, such as nigrosine, in producing Early English and other dyes. Such chemicals as sugar of lead, potassium chromate, and magnesium sulphate, are sometimes valuable in use with acid aniline and other coal-tar colors.

Tannic acid used in connection with other substances produces interesting, valuable, and sometimes troublesome colors. When it is used in connection with iron salts and ammonia, a ferric ammonium tannate having a blue-black or olive-green color is formed. This combination is occasionally used as a wood-stain. It sometimes appears unexpectedly where it is not wanted, if tannic acid is used in contact with iron, as in a tin can, or when it is applied to wood with a tin-bound brush.

Sulphate of iron in dried form and chloride of iron can be used with tannic acid, and various tones of gray are the result. The water-soluble coal-tar dye called nigrosine, and some other colors, can be used with tannic acid alone or with iron salts added. A still different color can be secured by applying a five-percent solution of tannic acid and water, and following with a weak solution of logwood extract in hot water which may be mixed with various amounts of copper sulphate in a five-percent solution.

The tannins are complex compounds, and vary in composition depending upon their origin.[2] Solutions of tannins in water are liable to absorb oxygen from the air and change in composition. The action is rapid with alkaline solutions. For this reason mixtures containing tannic acid should be made up fresh. Solutions of tannic acid and water, if kept in a covered glass jar or bottle, will remain in good condition for several days.

Various alkalies are used to produce stains on wood. Frequently the alkalies are applied following an acid treatment and react with the acid to produce a new color. One of the most satisfactory chemicals to use in staining is bichromate of potash, which is dissolved in water in the proportion of one quart of water to a half ounce of the crystals. It makes a yellowish or golden-brown stain, and is sometimes used with vegetable mahogany dyes, and also with carbonate of potash or soda following a treatment of tannic acid, thus making an orange-brown color. Coniferous woods, such as pine, and many of the broad-leafed hardwoods, contain little tannin and should not be stained with potassium bichromate, because the stain which shows at first will fade unless there is a union with tannin to form a tannate and produce a color that is permanent and usually brown in tone.

Potassium-permanganate crystals dissolved in various proportions in cold water make another useful chemical stain. The crystals are of a violet hue, and make a solution of a similar color. The liquid should be sponged on the wood because the permanganate will soon destroy a bristle-brush. The wood will have a violet tone when the solution is first applied, but this gradually changes to an interesting brown, which varies with the strength of the stain and the kind of wood. Darker shades can be secured by the use of more than one coat, just as with water-stains. The ligno-

---

2. A. C. Newell, *Wood and Lumber,* "Tannins and Extracts of Wood," pp. 86-89.

cellulose of which wood is composed gradually and sometimes rapidly reacts with the potassium permanganate, leaving a brown deposit of hydrated manganese dioxide.[3]

Volatile and fixed are the two types of alkalies that are commonly used in chemical staining. Strong ammonia (26°) in a solution of water is the volatile alkali commonly found effective for staining, while the fixed alkalies are represented by caustic potash or caustic soda, and sometimes by potassium bichromate, copper sulphate, and potassium carbonate.

41. Necessary Precautions When Using Chemical Stains.—Brushes, preferably of the type called rubber-set, are generally used in applying stains to wood. For coarse woods rather stiff bristles are needed to force the stain down into the open pores. Strong alkalies and some of the acids may affect the bristles and soon ruin a brush, or the iron in a tin-bound brush may cause trouble, particularly when used with tannic acid. Some of the alkalies in common use that affect brushes to some extent, especially when used in strong solution, are potassium hydroxide, ammonia, sodium hydroxide, and the carbonates. A brush cannot be used with any of the strong acids. Weak acids in common use, such as tannic acid and pyrogallic acid, can be applied successfully with a rubber-set brush. The brushes should be washed clean with water and allowed to dry when not in use. Brushes made of vegetable fibers instead of bristles can be used in staining wood.

When a sponge is used in applying a chemical stain, the hands are apt to become badly stained, or the skin may be eaten out in tender spots such as the backs of the fingers and under the nails. Cylinder-oil, or some other mineral oil, vaseline, or similar heavy grease, may be coated over the hands in such a manner as to protect them from weak acids or alkalies when using a sponge to apply stains.

42. Preparation of the Surface Before Applying Chemical Stain.—The same care must be used in preparing the surface of wood for chemical-staining as for water-staining; see Chapters I and II. All glue must be carefully removed, or light spots will appear about or under the adhesive.

---

[3] A. W. Schorger, *The Chemistry of Cellulose and Wood*, p. 122.

43. Fumed-Oak Color with Fixed Alkalies.—A color very much like that produced on white oak by fuming with ammonia can be obtained on certain varieties of oak, chestnut, mahogany, gum, pine, and some other woods, by preparing the surface with a tannic-acid or pyrogallic-acid solution, and later on giving a coat of fixed alkalies in an aqueous solution instead of fuming. The procedure is as follows:

1. Raise the grain by sponging with water, allow to dry, and resand.
2. Coat the wood with No. 1 solution, made up of ½ oz. tannic-acid powder in one quart of water; or ⅓ oz. pyrogallic-acid powder in one quart of water. (The solutions may be mixed in these proportions in any quantity.) Allow the wood to dry.
3. Sand lightly with No. 000 sandpaper.
4. Apply a coat of No. 2 solution, made up of:
   1 quart water,
   1 oz. bichromate of potash,
   ½ oz. caustic potash.
5. When dry, rub with diluted linseed-oil, made up of:
   1 part boiled linseed-oil,
   3 parts turpentine.

On white oak the above procedure will produce a color almost identical with that obtained by ammonia fuming. It is very important, however, that each of the two solutions shall be thoroly worked into the wood. A stiff, rather coarse, rubber-bound bristle brush is best. On porous woods, such as oak, the stain solutions may not be forced well down into the open pores unless the brush is kept quite wet, and applied with vigorous strokes lengthwise of the grain. Unless care is taken in applying the solutions, many light specks will show in the open pores where the solutions did not penetrate properly.

Stains produced by acids and fixed alkalies penetrate about as deeply as water-stains, while those obtained by the fuming process with ammonia are better in that they enter into the wood much more deeply.

A slightly different, but pleasing color, can be produced on many woods by substituting for the No. 2 solution a mixture of about one ounce of bichromate of potash to the quart of water. The latter solution seems to be more efficacious when applied quite warm. A lighter tint of brown can be obtained by using part carbonate of potash instead of all bichromate of potash in the solution.

44. The Ammonia Fuming Process.—The fuming process has been much used during the past few years to produce a rich brown tone on white oak commonly known as fumed oak. Chestnut is another wood that is quickly and beautifully stained by this process because it contains a large amount of tannin in a form that readily reacts with ammonia gas, and these chemicals quickly change the surface of this wood to a dark rich brown hue when fumed and rubbed with linseed-oil.

Certain other American woods can be changed in color to some extent by the fuming process. Walnut and mahogany may be somewhat browned by fuming on account of the fact that they contain quite a little tannin. Doubtless some of the foreign woods that contain an unusual amount of tannin can be fumed successfully.[4]

The woodworker should not mix red oak with white oak in articles that are to be stained by this process, for the former does not react to ammonia as readily as the latter, owing to the fact that it contains much less tannin.

A chemical reaction takes place when ammonia gas unites with tannic acid, and a new compound is formed called ammonium tannate which is of a rich reddish or yellowish brown color.

---

[4] A. C. Newell, *Wood and Lumber*, "Tannins and Extracts of Wood," pp. 86-89.

Success in fuming wood to produce stain comes from technical knowledge and proper equipment. The finisher must know what woods can be fumed, and how to prepare and treat them before and after fuming.

45. The Fuming Process on White Oak.—White oak, the wood that is most commonly used when the fuming process is attempted, requires proper preliminary treatment. Fuming a finished and sanded article made of white oak may seem disappointingly slow. It can be hastened somewhat by sponging with water before putting the article in the fuming-box. The sponged wet wood can be fumed at once and sanded later on after removal from the box, or it can be dried and resanded to remove the fuzz and then fumed. Raising the grain of the wood with water seems to open up the pores and speed up the chemical action of the ammonia fumes.

Weak solutions of tannic or pyrogallic acid, or a mixture, applied to the surface of the wood, will greatly speed up the fuming process. For the mixture of tannic acid, use one ounce of tannin powder to one quart of water; for the pyrogallic-acid solution, which will produce a more reddish brown than can be secured from tannin alone, the mixture should be weaker, in general, with about ¾ oz. of pyrogallic-acid powder to the quart of water.

A mixture of the two solutions is excellent, and produces a color in the final finish slightly different from that produced by either acid used alone. None of the above mixtures should be put in tin containers, or applied with tin-bound brushes, or a blue-black color will result from the action of the acid on iron. Glass or earthen containers and rubber-set brushes should always be used.

Sap-wood streaks and boards from different trees are brought to a much flatter and even tone by the use of one of the acid solutions before fuming. This reduces the amount of "blending in" with stain to color the light places to the general tone of the piece. Wood that has been treated with one of the acid mixtures has a more uniform acid content on the treated surfaces, and after fuming has a much less varying and more even tone.

46. The Fuming-Box.—A fuming-box is the special article required for staining with ammonia. Large factories use a specially-built, practically air-tight room, which has an outside window for ventilation, to clear out the gas fumes as soon as possible, and to keep them from other parts of the factory. Of the various ways of introducing the ammonia gas into the fuming chamber or box,[5] the simplest and commonest is to use aqua ammonia in concentrated form, which is known to the druggist as varying from 26 to 35.7 per cent in strength. It should have a specific gravity between .906 and .880, the latter being the strongest of all. Household ammonia is too weak to secure good results. Usually, the liquid ammonia is placed in a tank and allowed to run into one shallow pan after another by slowly dripping. The ammonia gas is gradually liberated leaving water in the pans.

A fuming-box for the school shop can easily be built by students, using matched lumber, and making the tight or face joints on the inside of the box. A practical size is about 4′ x 4′ x 8′, as such a box will take a davenport, table, or any other article of furniture which is apt to be made in a school shop. A removable partition should be placed so as to make two boxes of about 4′ x 4′ x 4′, as one box of this size is ample for most school work, and less ammonia is required for a small box. About 1/4 pint of strong ammonia (26° or 28°) is required to charge the box. The inside of the box may be papered to close up the small cracks, if desired. The doors of the box should be fitted so that they will close perfectly over felt strips around the joints.

Articles to be fumed must be placed in such a way that the ammonia gas can reach all the surfaces to be stained. If one article is laid upon another, the gas will not properly color the surfaces that are in contact, and light unstained places will be the result. All surfaces that are to be stained should be separated. Small articles can be leaned against the sides of the box in such a way that all surfaces will be exposed. Ammonia can be poured into a large flat dish or pan which is placed near the door on the bottom of the box. In pouring out the ammonia care must be taken not to splatter the liquid on any of the articles, or disagreeable spots that cannot be removed will be the result. A person should be careful not to breathe the fumes of ammonia when charging the box.

---

[5] W. K. Schmidt, *Problems of the Finishing Room,* Chapter XX.

47. Time Required for the Fuming Process.—The length of time required for fuming to a given shade of brown varies with a number of conditions, such as the species of wood, the preparation of the surface, the strength of the ammonia, and the size and tightness of the box. In a commercial fuming-room, in which concentrated ammonia drips from one warmed pan to another, articles of white oak that have been sponged with a tannic or pyrogallic solution, as described in a previous paragraph, will fume in about twelve hours. In the box described for the school shop, furniture treated with a tannin solution will fume in about 18 to 24 hours from ammonia in a flat pan. If the surface of the wood is simply sponged with water to open up the pores instead of being treated with one of the above acids, the time for fuming is generally doubled. Articles made of chestnut will usually fume in about one-half the time required for white oak. Chestnut wood does not usually require the preliminary coat of tannic acid; and care must be taken, or the color will be too dark.

48. Testing for Color.—The color of fumed wood is not a rich brown when it comes from the fuming-box; but is gray, like an old weathered fence-post, if the article be of white oak. A test for color can be made by wetting the finger or a piece of waste with linseed-oil and touching the wood in some inconspicuous place. The oil will instantly change the gray to the rich brown color so much admired. If the resultant color after application of the oil to a small spot is too light, the article can be returned to the fuming-box and refumed by adding new ammonia. If the color is too dark, allow the article to stand a few weeks before oiling; and it will probably fade somewhat.

To avoid opening a fuming-box before the fuming process is completed, some operators use a sample piece of the same kind of wood, prepared in the same manner, which is inserted thru a small opening in the box, and removed for testing.

After removal from the box, the fumed surfaces should be sanded lightly with No. 000 sandpaper in the hand or over a soft felt block. The stain penetrates quite deeply into the wood, much deeper even than water-stain; therefore, there is little danger of sanding thru the stained layer and causing streaks or spots. Reasonable care should be taken on the corners.

49. Securing Uniform Results.—Sap-streaks and light spots are a *bête noire* to the wood-finisher who uses the fuming process. Boards taken from different trees of the same species vary in the amount of tannin content; consequently, an article made from several boards will be uneven in color, or tone at least, after the fuming process. Various methods of blending or touching up are used to secure a more uniform tone. One of the best procedures for correcting the trouble is to ‘‘blend in’’ a fumed-oak water-stain of a color similar to that of the darker parts of the article. The line of demarcation between the light and dark tones should be dampened with a soft brush and water, and before this dries the stain in rather dilute form should be applied to the lighter areas. The same process may be repeated, if necessary, to secure a still darker tone over any portion of a surface. When whole boards or large portions of the article are lighter than other portions, the darker parts may be covered with diluted linseed-oil; the lighter parts may be coated with the tannin solution a second time; and then refuming will greatly darken the unoiled portions and only slightly affect the oiled wood.

Some finishers prefer a stain made of bichromate of potash and water-soluble jet black. Only a little of the jet black is needed to give a brownish tone. The bichromate of potash is a fixed alkali, and, with tannic acid, generally produces on oak a color similar to that secured by the volatile alkali, ammonia. This staining process can be repeated, if necessary. It is a little easier to tell what the resultant colors are going to be if one wets the surface containing the uneven tones with naphtha and allows it to dry before applying the bichromate of potash solution. Colored shellac may also be used, as a last resort, if the article has already been shellacked and shows an uneven tone. The shellac should be thin, and the amount of color added must not be great, or the effect will be muddy, or the grain will be much obscured and the shellacked portion may be too dark.

Use the following mixture if it is necessary to add a considerable amount of color:

½ pint liquid white shellac,

½ pint denatured alcohol, with ¼ oz. Bismarck brown spirit-soluble aniline dye dissolved in it,

½ pint denatural alcohol, with ¼ oz. (or less) of alcohol-soluble black dye.

Each solution should be mixed separately before pouring together, gradually adding the black solution, however, until the correct color is obtained. Other spirit-soluble colors may be used to produce a more accurate tone when applied to the light portions. The chief objections to this method of evening up tones are that spirit-soluble stains are somewhat fugitive, and the grain is obscured to some extent. The effect is somewhat like that produced with varnish-stains.

Oiling with boiled linseed-oil is the next step after sanding and staining sap-streaks, and this brings out the real color which is clear and transparent with no pigment to obscure the beauty of the grain. The oil should be diluted with about three parts of turpentine or naphtha. Raw linseed-oil warmed or heated can be used to great advantage, but it dries very slowly, and slows up the finishing process. The diluted boiled linseed-oil penetrates the wood deeply and leaves no gum or residue in places that are difficult to rub.

Slightly better results can be obtained by giving the fumed wood two or more coats instead of one of the diluted boiled oil, rubbing it well into the wood first with an oil-soaked pad and later with dry or nearly dry rags, waste, or other cleaning material. The oil should be allowed to dry two or three days between coats, and even longer, if possible, before any other finish is applied over it.

50. Procedure for Fumed-Oak Finish.—The steps in finishing an article of white oak, in chronological order, are as follows:

1. Raise the grain of the wood, by sponging the surface with water, and then allow it to dry.

2. Resand the entire sponged surface, to remove all fuzz which always appears on wood after wetting it with water.[6]

3. Apply a coat of a tannic-acid solution containing about ½ oz. of tannic-acid powder to the quart of water. (Use part or all pyrogallic-acid solution for a more reddish tone.) If none of these acids is at hand, open the pores by sponging with water, and fume longer.

4. Fume in a tight fuming-box or room for 6 to 48 hours, depending upon the box, the strength of the ammonia, the wood used, and the shade of brown desired. Use approximately ¼ pint of 26° ammonia in charging a box having 64 cubic feet of space.

5. Test for color with a spot of oil in an inconspicuous place on the article. Another coat of tannin solution may be applied and the article refumed for a darker color.

6. Stain all sap-streaks to even up the color. Slightly stain any boards or portions that are too light.

7. Sand the surfaces lightly with No. 000 sandpaper.

8. Apply one or two coats of diluted boiled linseed-oil (1 part oil to about 3 parts turpentine), and always allow two or three days between coats for drying. Rub the oil

---

[6] See Section 11, "Sponging and Resanding," p. 33.

after applying it, and remove all excess with nearly dry waste or rags.

9. Shellac with diluted denatured-alcohol shellac, consisting of 2 parts liquid white shellac, ½ part orange shellac, and 1 to 2 parts denatured alcohol. The shellac should dry from 8 to 24 hours.

10. Sand very carefully with No. 000 sandpaper.

11. Apply at least two coats of floor-wax, and rub to a polish about 15 minutes after each waxing. Instead of waxing, some finishers prefer to varnish over the shellac coat with a flat or dull varnish for the last process. Varnish should not be put over wax without removing the wax with gasoline.

REFERENCES—CHAPTER VI

Chemical Stains

H. R. Jeffrey, *Wood-Finishing*, Chapter II, pp. 30-39.

A. A. Kelly, *The Expert Wood-Finisher*, "Fumed Oak," pp. 45-49.

G. M. Nyman, Industrial Arts Magazine, Vol. 12, No. 6, June, 1923, p. 232.

A. C. Newell, *Wood and Lumber*, "Chemical Analysis of Wood," pp. 73-8; "Tannins and Extracts from Wood," pp. 86-9.

W. K. Schmidt, *Problems of the Finishing-Room*, Chapters 20, 21, 22, 23, 35 and 69; Formulas, pp. 367-8.

W. K. Schmidt, Furniture Manufacturer Magazine, "Fuming," January, 1923, p. 13, and June, 1925, p. 296.

A. W. Schorger, *The Chemistry of Cellulose and Wood*, p. 122.

F. N. Vanderwalker, *Wood-Finishing Plain and Decorative*, pp. 67-84.

CHAPTER VII

COLORS AND WOOD-STAINS

51. Colors Used in Wood-Staining.—The colors which are most commonly used by the wood-finisher at the present time are red, orange, green, brown, and black. Other colors in combination are frequently put together, often shading into neutral grays. Yellows and blues, while not used in the finishing-room in their pure form, are needed for mixing with other colors.

52. Definitions of Terms.—A statement of the meanings of *hue, chroma, tint, shade,* and other terms, as used by the discriminating colorist may be of some help to the wood-finisher.

Hue is frequently used in the sense of *color,* as red, yellow, and so on. It is also employed in referring to a *variation* of a color as a result of mixing a small quantity of another color with it. Thus we say that the hues of blue spread out toward the violet-blues on one side, and toward the green-blues on the other. To the scientist, hue means a color of a definite wave-length.

Chroma refers to the strength, brilliancy, or intensity of a color. We can say that chrome-yellow is a brilliant color of high chroma; or that it is a strong color, while yellow-ochre is a dull color of weak chroma. Colors lose in chroma or intensity as a result of being neutralized or grayed.

Shade refers to the darker effects produced by adding black to a color. In a broader sense the term shade is now commonly used to include the tints of lighter steps of a color, as well as the darker effects. The shade of a color in its exact meaning refers to a spectral or brilliant color to which black has been added thus lowering it in tone.

A tint of a color is a lighter effect produced by adding white to an oil-color or water to a transparent stain. A tint is lighter and more delicate than the standard color which is the spectral hue.

The *value* of a color refers to its position in a scale from dark to light. The tints and shades are therefore various values of the color itself. Black or white may be mixed with a color, and a change of value is the result; but there is no change in the hue or color itself otherwise.

Tone usually refers to the general effect, as "painted in dark tones" means that the effect is dark. Tone has reference to the degree of luminosity or power of reflecting light possessed by a color. Adding black or white to a normal color changes its tone.

Saturation of a color refers to its purity, or to the amount of white light which is contained in the color. White in the form of pigments, of course, has no hue and no saturation.

Warm colors are the fire colors represented by red, orange, and yellow. Red is sometimes called a hot color.

Cold colors are the ice colors of blue, and its neighbors in the spectrum, green, and violet. A yellow-green may be called a warm green, and in the same sense a red-violet is a warm violet.

53. Colors of the Prismatic Solar Spectrum.—White light or sunlight has been known to be composed of seven prismatic colors, at least since the time of Newton who pointed out this fact in the year 1666. When a beam of white sunlight is passed thru a prism, refraction breaks it up into a band which shows the seven colors of the rainbow, namely: red, orange, yellow, green, blue, indigo, and violet. Some of these colors are not primary colors, however, for they can be produced by mixing other colors together.

54. The Three Primary Colors.—For many years *red, yellow,* and *blue* have been called the primary colors because it was thought that they cannot be made by mixing pigment-colors together. A statement of this fact is found in the writings of Aristotle who lived about 2300 years ago. The name primary colors still clings to red, yellow, and blue, altho it is now claimed that these so-called primaries can be made by mixing colors adjacent to them on the color-circle.

Sargent says that red can be made by mixing violet and orange; that blue can be made by mixing green and violet; and that yellow can be produced by a mixture of orange and green.[1] The three so-called primary colors which are produced by mixtures of adjacent colors on the color-circle are apt to be what most people call tertiary colors. They are dull and low in brilliancy, and appear like bright colors that have been grayed. Practically it is best for the pigment-color mixer to have brilliant reds, blues, and yellows to start with, and then to make the other colors, considering the three hues just named as base, fundamental, or primary colors.

55. Secondary Colors.—Red, yellow, and blue pigments when mixed together in pairs produce new hues called secondary colors. Red and yellow make *orange;* yellow and blue produce *green;* and red and blue give *violet.* The above refers to mixing of pigments or dyes, and not to combining colored lights. Sargent tells us that blue and yellow lights blended together produce white; and that disks of the same colors when rotated produce gray; while pigments of a similar blue and yellow when mixed as stains or paints produce green.[2]

The artist and mixer of paint or stain should keep these facts in mind and not be confused by the many color theories of the scientist who works with lights rather than with pigments. The artist or wood-finisher who mixes pigments or dyes in making other colors considers red, yellow, and blue to be the primary colors; and orange, green, and violet are regarded as the secondary colors. Some writers and colorists use the term *purple* in place of violet; and, generally, the colors purple and violet are considered to be the same or nearly the same.

---

[1] Walter Sargent, *The Enjoyment and Use of Color,* pp. 157-161.

[2] Ibid., pp. 108-112.

56. Tertiary Colors.—By mixing the secondary colors, orange, green, and violet, in pairs we have a new series of hues known as *olive, citrine,* and *russet,* which are called tertiary colors. Orange and green mixed in the right proportion produce citrine; green and violet make olive; and orange and violet combine into russet. In mixing colors for citrine, which is also called citron, four parts of orange and one part of green are required. Olive is made from four parts of green to one part of violet. Russet is obtained by taking four parts of orange and one part of violet.

57. Quaternary Colors.—The quaternary colors are obtained by mixing together the tertiary colors in pairs.[3] By combining pigments of citrine and russet we have *buff;* russet and olive produce *plum;* and citrine and olive make *sage.*

58. Complex Mixed Colors.—Many other colors can be produced by mixing primary, secondary, and tertiary colors together in various proportions. The color which results from any mixture depends upon the chroma or brilliancy of the primary colors used as the original pigments, and also upon whether black or white has been added. The strength of the color can sometimes be changed by dilution with various liquids, as by adding water to water-colors or turpentine to oil-stains.

59. Neutral Colors.—*Black and white,* while not colors in the ordinary sense, are known as neutral colors. They can be used for contrasting effects with any of the other colors and make a color harmony. Black and white are often mixed with any of the colors to make tints and shades. When mixed together they make a gray. Any color can be neutralized or changed to a neutral gray by adding a sufficient amount of its complementary color.[4]

60. The Color-Circle.—Many authorities on colors arrange twelve of the colors of the spectrum in a circle using red, orange, yellow, green, blue, and violet, with intermediate or half steps between. Some writers use ten steps instead of twelve in the color-circle.[5] Walter Sargent, William H. Varnum, William J. Miskella, of the Finishing Research Laboratories, Ch. Coffignier, of Paris, France, use the color-circle divided into twelve parts.[6] This plan enables one to select approximately color harmonies in triads as well as with opposites on the circle, Fig. 7.

---

[3] William J. Miskella, *Practical Color Simplified,* pp. 20, 21.

[4] See Section 61, "Complementary Colors," p. 82.

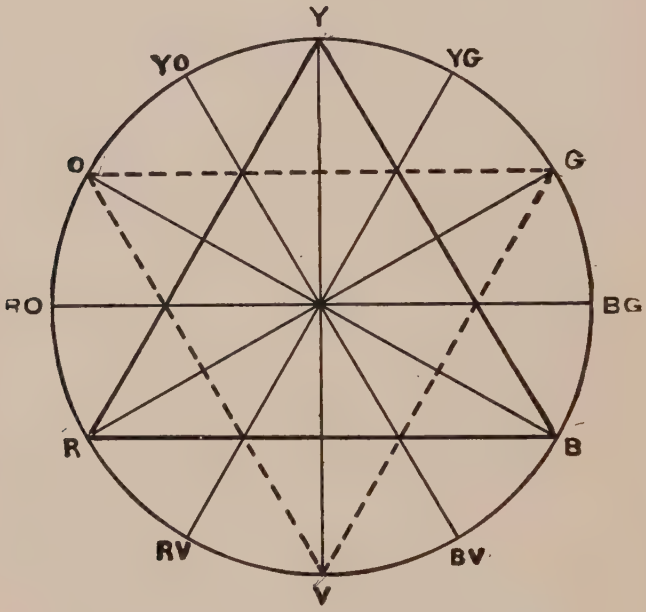


FIG. 7—THE 12-STEP COLOR-CIRCLE WITH TRIADS

61. Complementary Colors.—Effects that can be produced by mingling or blending lights cannot be reproduced by mixing pigments. The complementary colors in the two cases are not exactly the same. The pigment-complement of any hue can be found by what is known as the after-image.[7] One method of seeing the color of an after-image is as follows: (1) Select a piece of bright-colored paper, as yellow; (2) Make a tube of dark paper, or use one hand as a tube to cut off the surrounding light, and look thru one of these "telescopes" at the colored paper for some time, as half a minute or until the eye becomes tired; (3) While still looking thru the tube, remove the paper or look at a white background. An after-image of the complementary color will be seen for a few seconds as a rather faint but definite hue. If one looks at yellow paper thru the tube until the eye is somewhat tired, as suggested, the after-image which appears on a white background is a violet or possibly a blue-violet color. Violet is opposite to yellow on the color circle and is called the complementary color of yellow.

---

[5] A. H. Munsell, *A Color Notation*, p. 28.
[6] Walter Sargent, *The Enjoyment and Use of Color*, p. 10.
William H. Varnum, *Industrial Arts Design*, pp. 195, 196.
William J. Miskella, *Practical Color Simplified*, p. 14, and Plate VII.
Ch. Coffignier, *Colors and Varnishes*, p. 6.
[7] Walter Sargent, *The Enjoyment and Use of Color*, pp. 104-111.

The pigment-complement of a color is the color which mixed with it produces a neutral gray.

The approximate complement of any pigment-color can be found by looking at the opposite ends of any diameter on the color-circle, Fig. 7; thus, green is complementary to red; violet is complementary to yellow; orange is complementary to blue; yellow-orange is the complement of blue-violet, and so on.

62. Contrasts.—Effective contrasts can be secured by using black or white adjacent to a color, or by placing complementary colors side by side. A neutral gray can also be used with colors if a less striking or more subdued contrast is wanted. One or both of two complementary colors may be omitted, and the colors adjacent to either one on the color-circle substituted for the broken-up hue, in order to produce more subtle or delicate contrasts. An illustration of broken-up colors can often be seen in the morning or evening sky, at sunrise or sunset, where the clouds vary from red-orange to orange and then to yellow-orange, and all are contrasted with blue which also may vary.

63. Color Triads.—An equilateral triangle of the proper size, so that the three points of the angles just touch the circumference of a color-circle, when the triangle is placed over the circle, will divide the color-ring into three equal parts. The points of the triangle will, in any position that it is placed, point to three colors that are approximately harmonious, because any two mixed together will produce the complement of the third color.

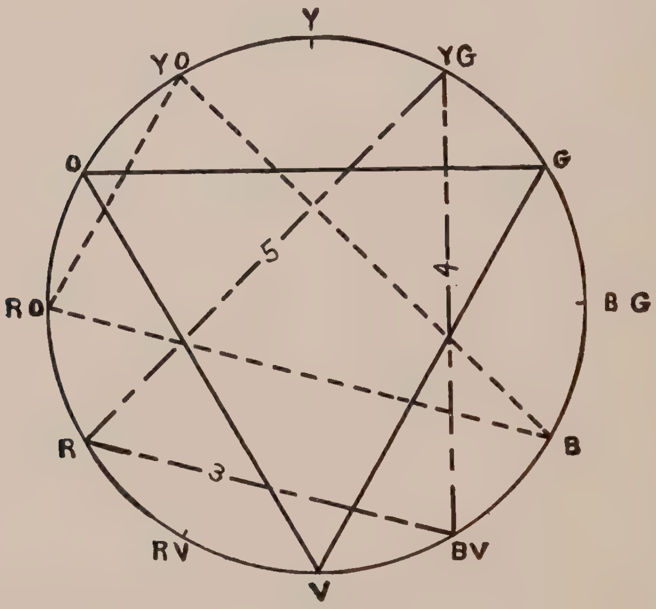


Fig 8—Color Triads and Near Complements

In Fig. 8, *O-V-G* represents a triad or three-color harmony with contrasting colors. The triangle *B-YO-RO*, which is shown in dotted lines, represents a color, blue, with its near-complements yellow-orange and red-orange. The use of a color with its near-complements is generally effective producing softer and more delicate contrasts that are often of great beauty.

A very great number of interesting color combinations can be discovered by shifting the triangles in Fig. 8 about the color-circle. If the equilateral triangle is placed with corners at *Y-B-R*, we have a combination of the three primary colors, which is the least pleasing of the harmony groups made by placing the triangle over the color-circle.

Another pleasing combination, recommended by some artists, is made by the use of a triangle with three, four, and five steps on the sides, as shown at *R-BV-YG,* in Fig. 8. Triads containing one of the so-called primary colors can be used in such a combination without the unpleasant group of the three primary colors. In some cases two of the primary colors, such as blue and red, may be included in a triad. If the *3-4-5* triangle in Fig. 8 is revolved one step counter-clockwise, a color triad with yellow, red-violet, and blue will be the result.

64. Color-Harmony.—It is very difficult to lay down fixed rules as to just what colors are pleasing when they are placed together. Each color has an unlimited number of variations changing toward the adjacent hue on each side of it on the color-circle. Each hue has many values which may be produced by dark and light, or by mixture of black and white. The chroma or intensity of colors varies from full brilliancy to neutral gray. The texture of the material to which the color is applied gives different effects of light and dark as well as of tone and of reflection.

Color-harmony, in general, can be secured: (1) by a careful selection of the proper hues, either analagous, or related, or in contrast; (2) by having one color dominant; (3) by having the colors selected and arranged for a tone balance;[8] (4) by considering lights and darks of the hues or shades and tints; (5) by varying the chroma, or partially neutralizing one or both of the colors; and (6) by selecting hues suitable to the texture of the material or surface upon which they are to be applied.

65. Analogous and Contrasting Colors.—There are two types of color-harmonies, which are known as *analogous* and *contrasting* harmonies.

Analogous colors are closely-related colors, or those that are adjacent to each other on the color-circle. An example of a group of analogous colors is red-orange, orange, and yellow-orange, as shown on Fig. 8. This type of color-harmony produces delicacy, softness, and attractiveness. It lacks contrast and boldness; but brings refined beauty, which under many conditions is very suitable and pleasing. Analogous colors are much used in decorative schemes for the home, and in women's costumes.

---

[8] E. A. Batchelder, *The Principles of Design,* p. 135.

Contrasting colors may be made harmonious thru a tone balance in several ways: (1) There may be a color-contrast harmony, thru the use of a color and its complement. Such colors are found at the ends of any diameter on the color-circle, as yellow and violet. The areas covered by the two contrasting colors are often quite different in producing a harmony by contrast. (2) One or both of the colors may be subdued or grayed in a contrasting color-harmony. (3) The values of the colors in the contrasting pair may be varied enough to secure a pleasing tone balance. The values are changed by making the colors darker or lighter.

66. The Modern Theory of Color.—The old theory that red, yellow, and blue are the primary colors is still the basis for mixing colors in many trades and industries, and seems to be generally used in public schools. Modern scientists in experimenting with light-ray colors have come to the conclusion that light rays separate into red, green, and violet-blue as the basic or primary colors. Students of color, such as A. H. Munsell, use a five-point color-circle, with intermediate half steps.[9] This new color-circle is made up of red, yellow, green, blue, and purple, with the intermediate colors, yellow-red, green-yellow, blue-green, purple-blue, and red-purple, Fig. 9.

Modern research has shown that no mixtures of other light rays will produce red, green, and violet-blue, and for this reason these three colors are called primary colors. Other colors can be produced by mixing light rays from the three colors: dark red, green, and violet-blue.

It must be remembered that mixing the rays of colored lights and mixing pigments or dyes are very different things. The spectral colors all come from white light, and they can be recombined into white light by the use of a second prism, which must be inverted and placed so as to gather the rays of light that have been dispersed into a spectrum by a similar prism, which originally broke up the white light into spectral colors.[10] If pigments of the same spectral colors are mixed together, the result is not white, but gray. This shows plainly that we cannot mix pigment-colors by the same methods that are used in combining light rays and secure similar results.

---

[9] A. H. Munsell, *A Color Notation*, p. 28.

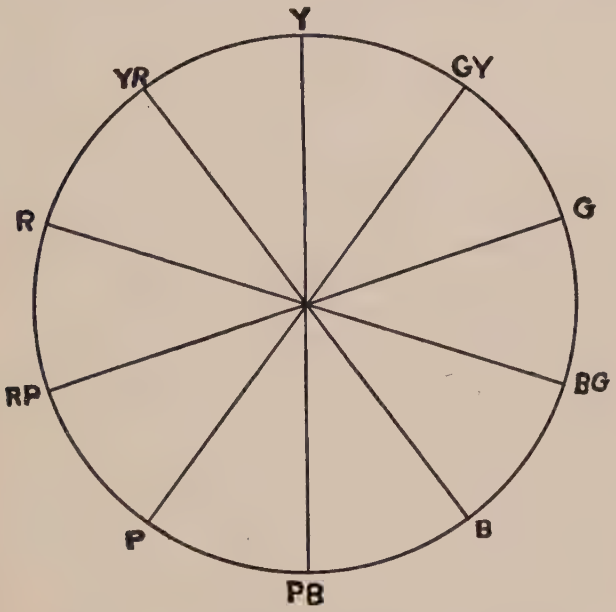


FIG. 9—THE MODERN TEN-POINT COLOR-CIRCLE

The complete list of contrasting colors can be made by observing the names of colors which are located at the opposite ends of the diameters of the circle.

The contrasting colors which are at the ends of the diameters of the ten-point color-circle are very pleasing. With the five basic colors—red, yellow, green, blue, and purple—other colors can be secured by mixing. The color-harmony is not quite the same as that obtained from the old theory of six colors with a twelve-point circle. According to this new theory the complementary color of red is blue-green; the complement of green is red-purple; and that of purple-blue is yellow.

---

[10] Ibid., Section 92, p. 41.

67. Acceptable Color-Combinations.—The amateur colorist should not allow himself to become confused by the two theories and two methods of mixing colors. Both methods are used at the present time, and both are offered in this book in order to meet the needs of persons who have learned one method and do not understand the other. While it is probably true that the new theory is more scientific and produces more pleasing complementary colors, the old system is still used more widely, and cannot be overlooked in a discussion of color mixing.

LIST OF GOOD COLOR-COMBINATIONS

1. Black and white.
2. Blue with gold, or orange, or maize.
3. Blue, with salmon, or red-orange.
4. Blue with black or white, or with orange added.
5. Blue with gold, crimson, and sometimes brown.
6. Red with red-orange, orange, or gold; black may be added.
7. Scarlet with violet, or black, or white.
8. Crimson with orange, or red-orange, or green.
9. Yellow with violet.
10. Green with gold, crimson, red, or orange.
11. Purple, red, and scarlet.
12. Gold with lilac, or blue-violet.
13. Lilac with scarlet, white, or black.
14. Gold with practically any color.
15. Black and white with any color.
16. Shades and tints of the same color are good together.

This list of colors which are thought to produce pleasing harmonies, is offered in the hope that it may be helpful to persons who are not experienced in selecting good combinations from one or the other of the color-circles. Another reason why this list is valuable is that it introduces two so-called colors—black and white—which are often employed to produce certain effects that are obtainable in no other way.

Some of the color combinations are analogous or closely related colors. A few of the pairs, such as yellow and violet, are complementary colors according to the old color theory, and are shown at opposite ends of a twelve-point color-circle. The combinations in the list are in general based on the old theory of three primary colors and a twelve-point color-wheel. It should be noted, however, that slight changes in some of the hues will make the combinations correct according to the new theory (Munsell) with the ten-point color-circle.

Hue is not the only characteristic of a specific color. It has already been pointed out in the section on Color Harmony that each color has a number of values which are known as tints and shades, and that brilliancy and partial neutrality must also be considered in arranging a pleasing color combination. In general, color combinations are most pleasing when one hue is dominant, and when shades, tints, and partial neutrality are all considered.

The wood-finisher of the present day should have a list of pleasing color combinations, a very good eye, and taste if he is to be successful in the use of paint enamels or lacquer enamels because colors are often demanded in various color harmonies for finishing close-grained woods that are now frequently used in making certain types of furniture. Let us suppose our colorist has an end-table that he wishes to finish with a body color of blue. The "List of Good Color Combinations" will indicate several possible colors that can be used as trimmings. Such a list indicates that greater freedom can be used in some cases than would be apparent from a slavish following of the combinations indicated on either of the color-circles. Many other satisfactory color combinations in pairs or triads might be added to the list just given. The list, while not complete, suggests harmonies that are accepted by color critics in general.

68. Palette of Colors for Staining.—The wood-finisher can secure practically any color effect that he wishes by having a palette of the twelve hues shown on the color circle. The colors most used at the present time are browns, greens, reds, oranges, and blacks, in various combinations, sometimes in tints or shades, and again in tones that approach neutral grays.[11] Such primary colors as brilliant yellow and blue are not usually put on wood in their full strength and hue; nevertheless, they are valuable in mixing with other colors. It is necessary to have the primary colors, red, yellow, and blue, in full chroma or brilliancy if any of the mixed colors are to be intense and brilliant. Ivory-black is commonly used to darken or make shades of the various colors.

---

[11] See Table IV, "Coloring Natural Paste-Filler," p. 146.

REFERENCES—CHAPTER VII

Colors and Wood-Stains

Ch. Coffignier, *Colors and Varnishes,* pp. 3-10.

Arthur W. Dow, *Composition,* "Harmony," p. 114.

J. A. H. Hatt, *The Colorist,* "Palette of Colors for Painting," p. 54.

A. A. Kelly, *The Expert House-Painter,* "Selecting Color-Combinations," pp. 248-256.

A. A. Kelly, *The Expert Paint-Mixer,* Chapters I, II, X, XI.

F. Maire, *Colors—What They Are and What to Expect of Them.*

A. H. Munsell, *A Color Notation.*

William J. Miskella, *Practical Color Simplified.*

A. B. Pattou and C. L. Vaughn, *Furniture, Furniture-Finishing, Decoration, and Patching,* pp. 157-8.

Walter Sargent, *The Enjoyment and Use of Color,* Chapters III, V, and VI especially.

Emily Noyes Vanderpoel, *Color Problems.*

F. N. Vandewalker, *The Mixing of Colors and Paints,* Colored Plate, p. 152 especially.

William H. Varnum, *Industrial Arts Design,* pp. 194-215.

CHAPTER VIII

Dyes Useful as Stains

69. Sources of Dyes.—It is well known that the animal and vegetable worlds have been the sources of materials for dyestuffs for many centuries. The development of chemistry as a science, and the wonderful discoveries in this new field, have recently brought a wealth of new material to the dyer that has enabled him to produce all the hues, shades, and tints of the rainbow, and at small cost.

Chemical discoveries have come one after another since 1856, when it was found that a beautiful aniline dye could be made from coal-tar. This discovery proved to be a revelation which opened the way for the making of several hundred aniline and other coal-tar colors of many shades and tints. Some of these new colors have been found to be fugitive, while others are usually light-proof and permanent. In fact, many of the coal-tar dyes are known to be clearer, more brilliant, and far more permanent than were the much-prized, and greatly-extolled vegetable dyes that have been known and used for hundreds of years.

At the present time coal-tar dyes almost entirely dominate the dyestuff field. They furnish probably more than 95 per cent of the material used in wood-stains, and seem to be driving nearly all of the highly-prized colors of our ancestors from the market. Several very important industries of 75 years ago, such as the production of madder and indigo, have proved unprofitable, and are gradually disappearing from the world's business.

70. Definition of Dyestuff.—A substance which when in solution is capable of changing the hue and imparting a new and permanent color to a fiber, especially a textile fiber, is commonly called a dyestuff. Coloring-matter that will change a color for a brief time only, or that can be washed out, is not classed as a dye.

The chemist thinks of dyes, both artificial and natural, as complex compounds consisting of carbon associated with other elements, particularly nitrogen, hydrogen, oxygen, and sulphur. Such materials or substances are sometimes known as aromatic compounds.

71. Theories of Dyeing.—Chemists have for a long time debated the question as to just what dyeing really is. The puzzle does not yet seem to be settled. Three theories have been advanced to explain the phenomenon of dyeing: (1) the chemical theory, (2) the mechanical theory, and (3) the solid-solution theory.[1]

(1) The *chemical theory* is based on the possibility that a definite chemical compound called a color-lake is formed between the fibers of the material being dyed and the coloring-matter of the dye. Supporters of this theory say that animal fibers, such as silk and wool, contain animal acids and have the power to react with acid and basic substances, and that they do react and change in color with acid and basic dyestuffs. In the case of cotton fibers, which are inert chemically, an extra treatment with an acid or basic mordant is necessary in order to secure a change of color with dyes; the acid mordant going with the basic dyestuff, and the basic mordants (such as various metalic oxides) being used with acid dyes. There is very little direct evidence to prove the chemical theory. The fact that alcohol and some other solvents may remove the coloring-matter, and leave the fibers unchanged, seems to break down the strength of the arguments for the chemical theory to some extent.

(2) The *mechanical theory* is supported by possibility that the coloring-matter may be composed of fine particles, which are invisible even with a microscope, that lodge between the tiny imaginary molecules that are supposed to

---

[1] See J. M. Matthews, *Application of Dyestuffs*, pp. 582-606; or T. E. Thorpe, *Dictionary of Applied Chemistry*, Vol. 2, "Dyeing," p. 574.

be component parts of the fibers themselves. However, it is known that a given dye produces varying tones and nuances on different fibers, which in some cases are fast to light and in others are fugitive. Adherents of this theory sometimes say that the size of the molecules of the dye and different fibers may vary, allowing the coloring-matter to find a lodging-place in some materials and not in others to such good advantage.

To support this theory it is pointed out that, in general, hot dyeing is more effective than cold dyeing. This may be due to greater expansion in the size of the molecules of one material than of the other, thus permitting them to unite to better advantage and to form a different and new color. The mechanical theory is not thought by most chemists to be a satisfactory explanation of dyeing reactions on wool and silk, but some people still think that it really shows what takes place with cotton and possibly other vegetable fibers during the dyeing process. If dyeing were merely mechanical, it seems probable that repeated washings in boiling water would remove all the color. This cannot be done in many cases where permanent dyes have been used.

(3) *The solid-solution theory,* advanced by Witt, is more difficult to understand than either of the others, but it is now believed by many color chemists to be the most probable explanation. According to this theory, one solid substance, such as coloring-matter, may be dissolved by another solid, such as fiber, just as molten glass may be colored by absorbing certain pigments.[2] The fibers being dyed act as solvents, which absorb certain coloring-matter from the dye solution. In some cases, mordants, which are of three classes, may enter into the dyeing operation.

72. Mordants.—Mordants change and increase the affinity of some fibers for dyes. Their use is necessary with certain dyes especially the old fashioned vegetable colors, some of which required complicated treatments with mordants in order to make the dye "bite." Vegetable fibers will combine with certain tannin mordants, such as tannic acid, cutch, and sumac; while wool will form color-lakes with various dyes, if first treated with metallic oxides, such as those of aluminum, iron, and chromium, which prepare the fibers to react properly with the dye and absorb it. Oil mordants, such as Turkey-red oil, are sometimes used in fixing basic dyes on cotton.

---

[2] See J. M. Matthews, *Application of Dyestuffs,* pp. 582-585.

Mordants are sometimes classified under three heads: *tannin* mordants, *metallic* mordants, and *oil* mordants. Other names are used also, but these seem to be the most distinct types.[3]

ANIMAL DYES

Previous to the year 1856 certain important animal dyes, such as cochineal and Tyrian purple, were in common use. The kermes insects were also the source of a valuable red or reddish purple dye known and used even in very ancient times.

73. Cochineal.—An insect commonly found in Mexico and Central America, produces the raw material for crimson, scarlet, and purple lakes, the color usually being called carmine or carmine lake. Natives who were using a red dye were found by the Spaniards in 1518, Their descendants still collect the coccus cacti insects from trees, and heat them in kilns until they are killed. The dried insects are packed in 160-lb. bags, and sold on the market as cochineal. The various cochineal-lake colors are made from the dried insects by boiling and treating the bodies with chemicals which produce several excellent dyes in shades of red. The colors are used in paints for high-grade coach bodies, and also for coloring food and cosmetics. Similar and more permanent coal-tar dye colors are gradually replacing cochineal colors for various purposes. Old contracts with certain English dye-houses have, however, continued the use of cochineal for dyeing the redcoats of the English army, altho coal-tar acid dyes are now cheaper and easier to apply.[4]

---

[3] See Geoffrey Martin, *Industrial and Manufacturing Chemistry*, "Organic," pp. 548, 549.

74. Tyrian Purple.—This is another old-time dye of a light violet-purple color which was greatly valued at least 1000 years before Christ. The dye was of animal origin, being made from a shell-fish. Pliny in his "*History of Nature*" describes the methods used in obtaining the coloring-matter and the manner of applying the dye to fabrics. The Phoenicians, famous in early times as dyers, probably originated and introduced Tyrian purple which was used on royal robes on account of its beauty and great cost. Modern chemists prepare practically the same dyestuff synthetically, and it is used as a "vat dye."

Sepia is another fish-dye, and is made from the common cuttlefish.

75. Kermes.—The *kermes* insect, found in certain oak trees growing near the Mediterranean Sea, was used for many centuries, especially before the discovery of America and the finding of cochineal, for important red and purple dyes. This dye was known to the Egyptians before the time of Moses, and it is thought that the beautiful scarlet of the curtain of the Tabernacle of Bible times was the result of dyeing with kermes, sometimes called "kermes berries."[5] This material was thought to be of vegetable origin until the eighteenth century, when it was discovered that the kermes coloring-matter comes from insects and is somewhat similar to cochineal.

VEGETABLE DYES

The earliest dyes used by man in times of antiquity were evidently secured from vegetable sources. The Bible mentions the "blood of grapes" for dyeing garments. More permanent colors were produced in India and Java in very early periods by the use of a dye from yellow juices of plants, which turned blue when the garments were exposed to sunlight and air. Textiles from the ancient tombs of Egypt, and the very old Hindoo temples of India, and clothes and blankets found in very early times in the Incan graves of Chili and Peru—all seem to have been dyed with some form of indigo. The Romans in their glory imported indigo from India and called it "*Indicum*" (Indian).

---

[4] See Charles E. Pellew, *Dyes and Dyeing*, p. 19.
[5] See J. M. Matthews, *Application of Dyestuffs*, p. 8.

After a sea route around South Africa was discovered, the Orient sent back such dyes as indigo, madder, Indian saffron, sandlewood, camwood or barwood, cutch, gambier, and probably other dyestuffs, part of which were picked up along the African coasts. The soft and permanent colors of the beautiful oriental rugs of past ages were largely made from "good old vegetable dyes." It should also be noted that other important dyes, such as logwood and fustic, were imported by the Old World from the West Indies and Central America after the discovery of the two western continents.

Wood-finishers of all ages have selected certain usable dyes from the larger list of dyestuffs known to textile dyers. In general, the wood-finisher has chosen colors that could be applied easily, thus avoiding the use of mordants and other after treatments, which are more successfully and conveniently applied to textiles than to wood. It should be remembered that practically all of the most permanent dyes that can be used in dyeing textiles by simple or direct processes can also be used in staining wood.

Some of the best known and most important vegetable dyestuffs[6] are the following:

76. Logwood Extract.—Logwood, still considered by some experts to be the world's most valuable material for making fast blacks, is made from logwood chips, imported principally from Mexico and Central America. Logwood extract can be treated or mixed with other substances, and will produce reds, blues, purples, and violets. As a dyeing material it is still highly prized, and is used in coloring wool, silk, cotton, leather, hair, and wood. It retains its place as an important dyestuff, especially for silks, very largely because good cheap blacks of great attractiveness can be produced by its use.

---

[6] See A. C. Newell, *Wood and Lumber*, pp. 60, 86-88.

Coal-tar blacks have, nevertheless, replaced logwood for some purposes, partly because some of them are even more permanent than this well-known vegetable dye. Aniline Black, Diamine Black, Columbia Black, Vidal Black and other synthetic colors are now used on cotton goods; while Naphthol and Naphthylamine Black, Diamond Black, Alizarine Black, Anthracene Black, Azoacid Black, and others, are used on wool and silk in place of logwood dyes.

Logwood is sold in the form of chips and sticks, also as a liquid extract, and in crystals. The red dye from logwood is obtained by boiling the dark red heart-wood chips, the coloring-matter being readily dissolved.

Until very recently logwood stains were much used by wood-finishers. The formulæ for black stain given by the wood-finishing books of a few years ago frequently contained logwood, but this good old vegetable stain is gradually becoming of less importance in the finishing-room because new coal-tar dyes are gradually replacing it. The coloring-matter from logwood was often mixed with other substances such as indigo, Brazil-wood, gallnuts or gall-apples, and madder, in preparing wood-stains of various colors.

77. Indigo.—The indigo plant supplies an old dyestuff that was gradually introduced into Europe during the fourteenth century, and which replaced a somewhat similar tho inferior blue dye called "*woad,*" after encountering serious opposition, especially in Germany. Indigo dye was made from the leaves and herbacious parts of the East Indian indigo plant. At present, Manila and Medras are the important shipping points for the natural indigo dye. This dye, used for making various shades of blue, was formerly considered to be the most permanent of all the old-time vegetable colors.

Synthetic coal-tar indigo, which is made from naphthalene, has recently very largely displaced the old vegetable dyestuff, because it is identically the same chemically, and is equal to the plant dye in fastness of color. The new colors are much more easily applied than the old. Strong claims are now made for certain synthetic indigo vat dyes which are said to have greater fastness to light than the old vegetable indigo colors which were the raw material for producing about 50 shades of blue. Many coal-tar colors, some of them being synthetic Indigo, Indoin, Methylene Blue, Diamine Blue, Immedial Blue, and others, are used on cotton; while synthetic Indigo, Alizarin Cyanin, Anthracene Blue, Gallamite, Sulphocyanin, and other dyes, are now common substitutes for the old vegetable indigo.

The wood-finisher of a generation ago used vegetable indigo dye in a number of stains for wood, especially when a blue or purple was wanted. Blue tones are rarely wanted on wood, hence indigo was not often used alone, but was rather frequently found in mixtures of various colors, especially with logwood in making shades of purple.[7]

78. Aloes Extract.—A dye produced from aloes is reported to come in greenish to violet colors. It is made from the leaves of certain aloe trees belonging to the lily family and growing largely in the old world. This extract is not very commonly quoted on the American market at present. Formerly it was occasionally used with alkanet root and dragon's blood in making brown stains.[8]

79. Madder Extract.—Until quite recently a dye was extensively made from the peeled roots of the madder plant, which was formerly grown in Holland, Germany, France, and the Levant as a perennial herb. The plants were probably imported after about 1507 from the East Indies where they seem to have originated. The colors which the madder roots produced were known as Turkey-red, madder brown, madder carmine, madder purple, and madder orange.

---

[7] See Fred T. Hodgson, *The Up-to-Date Hardwood Finisher,* Part II, p. 163.

[8] Ibid., p. 34.

Synthetic alizarine dyes which are made from anthracene have very largely displaced madder root colors, since the discovery was made that the active coloring-principle of alizarine is the same as that found in this vegetable dyestuff. Turkey-red and a few other related colors are still made from the roots of the madder plant, but the quantity produced has been greatly reduced since the discovery of cheap and practical methods of making coal-tar alizarine dyes. The objections to the vegetable madder colors are that they are not pure, and are not as clear and bright, even after the use of mordants, as are the synthetic alizarine dyes.

The old-time wood-finishers often used madder colors for wood-stains and mixed them with other dyes, especially when they wished light-proof tones of red and mahogany. Madder was a favorite red color, and was very commonly found in formulæ containing fustic and logwood. If madder colors are treated with the proper mordants, various tones of pink, red, yellow, purple, and even brown can be obtained.

Madder is reported to be the most important of all vegetable dyes sold on the market at present. The madder color that is most famous in history is known as Turkey-red.

80. Gallnuts.—To a limited extent blacks and some other colors have been made from gallnuts, also called *nutgalls.* Several grades from Alleppo and China are still found on the market. The coloring-matter from nutgalls was occasionally used with other dyes in the stains used by wood-finishers until very recently.

81. Cutch, or catechu.—This astringent brown extract is made from various plants imported mostly from Africa, and the East and West Indies, and is a valuable material for making pleasing and popular colors. Borneo produces a good grade which is commonly obtainable. Cutch is still popular to some extent for dyeing silk, especially when it is combined with logwood. For use on cotton goods, it has been largely displaced by diamine, benzo, and Congo colors, some of which require after-treatments.

Cutch is a tannin dye that has sometimes been used in connection with potassium chromate, or similar salts, in making reddish-brown stains for wood.[9]

82. Fustic.—A tropical yellowwood tree produces this valuable yellow dye, which is still commonly obtainable in sticks; but the chips, formerly used, are sometimes not found on the American market. Fustic extract is quoted, and is used in combination with various other substances to produce several shades of yellow, and sometimes browns or reddish tones. At the present time fustic is used chiefly with logwood in the production of blacks. The yellow dye is not now extensively used alone, because it has been replaced by coal-tar dyes of greater purity, permanency, and brilliancy of hue.

83. Turmeric.—An East Indian Ginger-Plant produces a yellow dye, which is shipped from Bombay. The yellow coloring-matter, called turmeric, can be treated with various chemicals to produce shades of yellow, and even greenish, reddish, and brown tones. The colors are somewhat fugitive in light, and are not much used at present for any purpose.

84. Osage Orange.—A stain which is almost identical with fustic is made from ''hedge'' or osage-orange trees growing in various parts of the United States.[10] It is obtainable both in powdered form and as a liquid extract, and is useful as a yellow to golden-brown dye. Its trade name is *Aurantine.* This new dyestuff, which was developed during the World War, shows practically the same qualities and reactions as fustic, and is used in the same manner. It produces tones which are slightly brighter and redder than those made by fustic.

85. Brazil-Wood.—A rose-pink dye is made from Brazil-wood, which is gradually going off the market; but it is sometimes obtainable, usually in the form of sticks or extracted liquor. The dye is weak and somewhat fugitive. Brazil-wood was formerly used in the manufacture of rose-pink lake, and the coloring-matter is frequently classed as a pigment. Wood-finishers formerly used Brazil-wood dyes compounded with gallnuts, cochineal, dragon's blood, saffron, or logwood in producing various red, purple, violet, and black stains.

---

[9] See A. C. Newell, *Wood and Lumber,* pp. 86, 89.

[10] See J. M. Matthews, *Application of Dyestuffs,* pp. 495, 496.

86. Red Sanders, or Red Sandalwood.—This wood is shipped in large logs or sticks, the heart-wood being ground and sold as powder. Sometimes the dyestuff may be obtained in bags in the form of chips. It makes a red coloring-matter which is soluble in alcohol and ether, but which is only slightly or sparingly soluble in water. It is obtainable in the ground form on the New York market, and is good as a coloring-agent for spirit-varnishes and, sometimes, for other purposes. Bombay is a shipping-point from which it is obtained.

Red sanders was formerly used in red spirit-stains, and was sometimes modified in color by mixing it with logwood extract and camwood dissolved in alcohol.

87. Camwood Bark.—The bark of camwood, in ground form, is the raw material for a dye which is occasionally used. It is obtainable on the New York market, but is not now in great demand. Camwood is also called *barwood.* In England it was formerly used as a dye for bandanna handkerchiefs.

88. Quercitron.—This dye is made from the inner bark of an oak tree (*Quercus citrina or Quercus tinctoria*) which grows in the east and southeastern parts of the United States, especially in Pennsylvania, Georgia, and the Carolinas.

While Quercitron is an American dyestuff it has been extensively exported to Germany. In this country, its use has largely been in the dyeing of woolen goods and leather, and in calico printing, where it is used with mordants of iron, chromium, tin, and aluminum. On the market it appears as a powder of a buff or yellowish color, and has an astringent taste.

89. Patent Bark.—This is the name given to a product of quercitron, made by boiling the bark in dilute sulphuric acid, then drying and washing the residue.

90. Flavin, or Flavine.—A yellowish-brown dry extract of quercitron bark produces very bright yellow colors in dyeing. It is sometimes used with cochineal to make bright scarlet-yellow colors. Flavine is the form of quercitron that is listed among the dyestuffs on the New York market. Neither fustic nor quercitron produces colors as brilliant and fast to light as those obtained from certain mordant dyes of coal-tar origin.

REFERENCES—CHAPTER VIII

Dyes Useful as Stains

Alberto Bachman, *An Encyclopedia of the Violin,* Chapter V, "Colors and Varnishes," p. 101.
Ch. Coffignier, *Colors and Varnishes,* Chapter III, "Pitches and Coloring-Matters," pp. 146-7.
Fred T. Hodgson, *The Up-to-Date Hardwood Finisher,* pp. 155-164.
F. Maire, *Modern Wood-Finisher,* "Fancy Colored Water-Stains," pp. 60-2.
Geoffrey Martin, *Industrial and Manufacturing Chemistry—Organic,* pp. 548-9.
J. Merritt Matthews, *Application of Dyestuffs,* "Historical," pp. 7-16; "Theories of Dyeing," pp. 582-606; "Fustic," pp. 495-6.
A. C. Newell, *Wood and Lumber,* "Gums, Chemicals, and Dyes in Heartwood," pp. 59-60, 86, 87, 88.
Charles F. Pellew, *Dyes and Dyeing,* "Historical," Chapter I.
F. M. Rowe, *Color Index,* Published by the Society of Dyers and Colorists (English), D. Van Norstrand Co., January, 1924. (Gives lists and brief description of all known coloring-matters).
Walter K. Schmidt, *Problems of the Finishing-Room,* "Stain Formulas," pp. 352-385.
T. E. Thorpe, *Dictionary of Applied Chemistry,* Vol. 2, "Dyeing," pp. 574.
F. N. Vanderwalker, *Wood-Finishing, Plain and Decorative,* "Dyewood Water-Stains," 89-91.

CHAPTER IX

Coal-Tar Dyes and Their Use as Wood-Stains

91. Characteristics and Origin.—Coal-tar, formerly considered an almost worthless waste product, is a very black, opaque, and thick mass, which is liquid at certain temperatures. It is formed thru condensation from gas in pipes during the manufacture of coal-gas, and is, therefore, a distillate from coal. The first coal-tar dyes were produced from aniline, which is one of the light tar-oil derivatives from nitrobenzene. Many other coal-tar dyes are derived, not from aniline, but from medium and heavy tar-oils, among these colors being many of the alizarine group.

In variety of tints and shades, and in brilliancy of hue, the coal-tar dyes are superior to all other dyestuffs. A French chemist is reported as having said that about 14,000 shades and tints of various hues can probably be made from coal-tar. Considerably less than one-tenth part of this number is now made and actually used. The exact number of colors listed in the "*Color-Index*" of the Society of Dyers and Colorists, is 1249.

The fugitive characteristic of many of the early coal-tar dyes has been overcome to a large extent. Chemically, some of these artificial dyes are practically the same as corresponding natural dyes. For example, the renowned "Tyrian Purple" is now made synthetically, and is known as *Dibromindigo*.[1]

92. All Coal-Tar Dyes Are Not Aniline Dyes.—The term *aniline* should not be applied to all of the synthetic coal-tar colors, because many of the dyes now manufactured are not made from aniline. Aniline is simply one of several derivatives from nitrobenzene, which is manufactured from light tar-oil. Many other coal-tar dyes are produced at present which are not related closely to aniline, but are made from other derivatives. The early basic dyes, such as Perkin's Mauve, Magenta, and Methyl Violet, were aniline dyes, while other colors came from coal-tar derivatives. To call all coal-tar dyes aniline dyes is misleading and wrong; nevertheless the term aniline is quite commonly used in trade circles to designate all coal-tar dyes. Whether the term aniline dyes will finally be used as a general name for all coal-tar dyes we do not know at present. Chemists do not now so use the term. Many people have the erroneous impression, however, that all coal-tar dyes should be called aniline dyes, partly because the term is often used in the more inclusive sense in the trade.

---

[1] See J. M. Matthews, *Application of Dyestuffs*, p. 9.

93. History of Coal-Tar Dyes.—*Mauve,* a fine purple color and a basic dye, was the first of the aniline colors. It was discovered by William Henry Perkin, an English student working under Hofmann in Germany in 1856. This new color, sometimes known as Perkin's Violet, was of great value and brought about a revolution in the dyeing industry and manufacture of colors. Other important coal-tar dyes, called anilines, were discovered by chemists within a few years.

Magenta, another basic dye and an attractive red, appeared in 1858 or 1859, about the time of the battle of Magenta in Italy, which occurred in 1859. In 1862 an aniline *black* was discovered by an Englishman, Lightfoot, and a *blue* was produced by Nicholson. *Methyl Violet,* also a basic dye, was discovered in 1866, and *Alizarine* appeared in 1868. Between the years 1873 and 1893 the following colors appeared: a sulphur yellow, called *Cachou de Laval,* in 1873; *Methylene Blue,* in 1877; the *Azo Scarlets,* in 1878; *Indigo,* in 1880; *Tartrazene,* an acid yellow, in 1885; and *Rhodamine,* a pink blue, in 1893.

Prior to the beginning of the World War in 1914 coal-tar dyes were manufactured in Europe, largely in Germany, and up to that time there had been little effort to make them in the United States. The war cut off further shipments of German dyes, and our country was without aniline and other synthetic dyestuffs from abroad for several years. The shortage became very great, because the raw materials required for coal-tar dye manufacture are the same as those used in the making of explosives. The very few factories in the United States which previously had made dyes had obtained their raw materials from Germany. Some of the most difficult problems that the dye manufacturers had to face were the lack of skill in the technology of dye-making, and lack of necessary experience and knowledge on the part of our chemists.

The lack of dyes in the United States gradually brought chemists and capitalists together, and factories for making raw materials and intermediates were slowly organized. Even tho the manufacture of explosives demanded practically all of the raw materials of some kinds which were available, the production of dyes was gradually brought about during the war. Peace left the United States with a number of dye factories that could manufacture colors from the more desirable raw materials. Such hues as Direct Black for cotton, a Chrome Blue especially valuable for the dyeing of wool, synthetic Indigo in large quantities, and Alizarine made from anthracene which was derived from our own domestic coal-tars, were being produced soon after the close of the war. About 175 colors including the most needed of the shades and tints of the standard hues, were put on the market late in the year 1918.

Before the war opened in 1914 the United States had imported not far from 350 different dyes from Germany. While at first some of the dyes of American manufacture were fugitive, because of the lack of proper raw materials, and the inexperience of our chemists and workmen in quantity production, the quality soon improved, until at present American dyes rank well with those produced abroad.

It is of interest to note that, altho a very large number of foreign dyes are still imported, the volume in small, being only about 5 per cent, while 95 per cent of the total tonnage used is now manufactured by our own dye-factories here in the United States.[2]

94. Products of Coal-Tar Distillation.—During the year 1845 Hofmann, a German chemist, discovered that the hydrocarbon, benzene, is present in coal-tar. Research students, especially the Englishman, Perkin, discovered Mauveine or Mauve somewhat accidentally when working with aniline, a derivative of benzene; and they found out that a beautiful violet or mauve color of tinctorial power is produced by the oxidation of aniline. Benzene (C_6H_6) is simply one of many coal-tar derivatives, as is also aniline which comes from nitrobenzene.

The various component parts of coal-tar are separated by distillation at various temperatures. The most important groups are indicated as follows:

1. Temperature up to 110°C. produce first runnings.
2. Temperature from 110° up to 210°C. distil out light and middle oils.

From the above two groups at temperatures under 150°C. benzene (C_6H_6), toluene (C_7H_8), xylene (C_8H_{10}), and their many derivatives are obtained. The boiling-point of benzene is 81°C. Toluene boils at 110°C., and xylene at about 130° to 141°C. Aniline comes from benzene thru its derivative, nitrobenzene. This so-called naphtha, or light-oil distillate, represents commonly only about 3 per cent of the coal-tar weight, and the yield of benzene is about 1½ per cent of the original tar.

3. Temperatures between 210° and 240°C. produce the heavy oils, known as the carbolic oils. In this group are found cresol, and especially phenol, and naphthalene ($C_{10}H_8$).
4. Temperatures from 240° up to 270°C. distil heavy or creosote oils. Much naphthalene is produced in the lower

---

[2] See R. Norris Shreve, "An Outline of the Dye Industry," Journal of Chemical Education, Vol. III, No. 11, 1926, p. 1263.

temperatures of this group, but little is present near the 270°C. temperature. Many hydrocarbons are mixed with coal-tar creosote oil, some of them being phenol, naphthalene, and anthracene, the last-named substance coming off at the highest temperatures, especially.

Coal-tar creosote is practically free from the light oils, which come off at the lowest temperatures, and "pitch" which remains as a residue at the temperature of 270°C. This creosote is similar in its properties to wood-tar creosote, and is used as a preservative. The creosote distillate represents about 10 per cent of the coal-tar weight, and may yield as much as about 8 per cent of naphthalene.

5. Temperatures between 270° and 400°C. produce anthracene or anthracene oil, also called "green oil." This distillate, considered to be the most valuable of all the coal-tar constituents, contains about 10 per cent of anthracene ($C_{14}H_{10}$) a liquid oil of high boiling-point, and several solid hydrocarbons, such as paraffine, chrysen, carbazol, and phenanthrene. The oils and solid materials are separated after cooling; and, after certain purification processes, a 50 per cent anthracene compound is produced, which is sold to the manufacturers of alizarine colors. Important reds, oranges, blues, violets, and greens of the alizarine group are made from anthracene, which in its pure state is a white crystalline substance.

Anthracene oil often represents about 11½ per cent of the weight of the coal-tar from which it is made.

6. Temperatures of 400°C. and above leave a residue or pitch which is a liquid but rather thick and viscous substance while hot. After the valuable anthracene is extracted, creosote or carbolic oils are often mixed with the hot pitch in order to produce a soft pitch or soft tar, some kinds of which are liquid at ordinary temperatures. Soft pitch commonly melts and is liquid about 60°C., while hard pitch melts at about 120°C.

Pitch, which is a very high-temperature distillate, frequently represents about 60 per cent of the coal-tar by weight.

95. Methods of Classifying and Naming Synthetic Dyes.—Two quite distinct classifications of dyes are now used. One is that made by the chemist, who classifies the dyes by their chemical structure, sometimes employing letters or numbers for further identification. This classification is a scientific system. The other method is a classification of dyes by their mode of application, or as the dyer or colorist groups them for use. The latter classification is practical and more intelligible to the ordinary user of dyes and stains.

The manufacturers generally use the chemist's method of naming colors. A large book called the "Color Index," edited by F. M. Rowe, authorized by the English Society of Dyers and Colorists, and sold in the United States by D. Van Nostrand Co. of New York City gives the names of all known dyes to the date of publication. Each dye is numbered in the book, and similar dyes of various manufacturers having slightly different names are grouped together showing that they are really the same. In the United States the dye-numbers given by Professor Gustave Shultz in his *Farbstofftabellen,* published in Germany, are most often used. The color-numbers given by these two authorities are not the same and should not be confused. The dye-numbers for each color by both systems are given in the *"Color Index."*[3] Experts use the individual dye-number with the name, and they can thus tell exactly the color and class of each dye.

The user can tell something of the color and class of dyestuff by learning a few things about how dyes are named by the chemists and manufacturers. Each dye is apt to have a trade name and a distinguishing letter to indicate the shade or tint; and also the manufacturer's or dealer's name may be shown. The chemist or manufacturing company discovering the color generally names it;

---

[3] See F. M. Rowe, *Color Index,* p. 317.

sometimes giving any appropriate name, but often using a word showing the chemical class to which the given hue belongs, or suggesting an indication of the physical properties or method of application, as "Newport Acid Violet 5 B Conc." The "5 B" indicates that the violet is nearly blue, being five shades away from the standard violet. If "5R" had been used the color would be five shades toward red from the usual standard violet, consequently the dye would be nearly red. The letters after the name often indicate colors, but they may be taken from a German word for a color, as "G" may mean yellow from the German word "*gelb.*"

The letter used often indicates the method of application of the dye, as "Alizarine Blue D," in which case the "D" refers to the method of application, meaning a "direct" cotton dye rather than a mordant dye. Fastness to light is sometimes shown by the letter "L" or "LL" the latter indicating a very fast color for a dye of its kind. The "*Color Index*" gives five degrees of fastness, numbered from one to five, the last being the least fast. It specifies various kinds of fastness, as fastness to light, to rubbing, to washing, to milling, to alkalies, to acetic acid, and the like. Sometimes the letters are only a part of the trade name and are given merely to help a manufacturer to identify a given shade of color.[4]

The particular quality of tone of a dye may be used in a name, as Croceine Scarlet or Malachite Green. Some dyes are named after prominent people as Bismarck Brown and Perkin's Violet, or sometimes after places as Erie, London, Congo, and Kashmir. Many dyes have names that indicate the chemical group to which they belong, as Azo Rubine or Methylene Blue.

The amount of concentration of a dye is sometimes indicated by an *X* or the abbreviation "*conc.*" or "*extra conc.*" All of these marks show specially strong coloring-matter. Degrees of dilution in strength are marked by

---

[4] See J. M. Matthews, *Application of Dyestuffs*, pp. 222-224.

Roman numerals, as Auramine I, II, III, the last-named being the most diluted.

The letters *S* and *SS* are used to designate dyes of exceptional solubility; while "*W*" after the name indicates, usually, that the color is for wool.

Dyes are sometimes mixed by the manufacturers, and given some name that indicates the color, strength, shade, or solubility. The names of such mixed dyes are likely to be still more confusing than those of single unmixed colors.

When the dye is given a Shultz number, it can be properly identified by the Shultz tables, and there need be no confusion.

96. Crudes and Intermediates for Dyes.—The crudes or raw materials from which all coal-tar colors are made are derived from distillation. The chief crudes used today are: benzene, toluene, xylene, carbazol, naphthalene, and anthracene—all made from coal-tar. Pure benzene, toluene, and xylene are quite well known volatile and colorless liquids. Naphthalene, carbazol, and anthracene are colorless solids in crystalline form. From the above named crudes, and two or three other minor ones, are made about 325 substances called *intermediates* in the dye industry.

From the light tar-oils benzene, toluene, and xylene are made; and from these crudes come intermediates called nitrobenzene, resorcine, phenol, and benzaldehide. From the medium heavy oils are distilled the crude naphthalene; and from this material are made such important intermediates as the naphthols, and naphthylamines, and the less valuable phthalic (thăl′ic) acid. The other important crude, anthracene, produces the intermediate anthraquinone, and from this material a very valuable series of alizarine dyes is manufactured.

The intermediate which is produced in the largest quantities at present is nitrobenzene, from which aniline is made. About one-half of the aniline manufactured in the United States is used in making aniline dyes, while the other half is used in the rubber industry for accelerators in the vulcanization of rubber.

In making the "intermediates," the "crudes" are treated with such materials as nitric acid, sulphuric acid, chlorine, caustic soda, lime, and nascent hydrogen.

CHEMIST'S CLASSIFICATION OF COAL-TAR DYES

Chemical structure is the basis of the classification of dyes used by the chemist. Some dyes are made by combining intermediates; others are manufactured thru processes of sulfonation, oxidation, or nitration. Many dyes, like the azo colors, are, however, the result of complex reactions.

The following are the most important of the chemical classes of dyes:

97. Azo Compounds.—The azo group is the largest class, and represents nearly half (605) of the dyes listed in the English "*Color Index.*" Azo dyes are found in several of the application classifications; some are neutral or acid, some are basic, while others may be direct; a number of them are mordant, and a few are spirit-soluble. The azo compounds of rather simple structure are usually yellow or red in color, while those of more complex constitution may be in the dark colors, such as black, blue and violet.

The *acid* azo dyes represent a large group of colors, and include many ordinary wool yellows, oranges, scarlets, blacks, such as Matanil Yellow, Tartrazine, Azo Acid Blue, Naphthol Black, Azo Orange (II, IV, G. etc.), Ponceau, Azofuchsine, and others.

The *basic* azo group is quite small, but contains the Safranine-azo colors (Janus Blue, etc.), Bismarck Brown, Chrysoidine, Tannin Orange, and New Phosphine.

98. Triphenylmethane Dyes.—This is a rather large class, and includes many of the brilliant colors with their various nuances. To this class belong many colors that are well known and much used. This group includes basic, acid, and mordant dyes, but none of the other application classes.

Acid members of this class include acid violets, soluble and alkali blues, wool blues, Acid Magenta which is the same as Acid Fuchsine, acid greens, patent blues, ketone blues, Neptune Green, Erioglaucine, and others.

99. Azine Dyes.—This group contains 46 colors as listed in the *"Color Index,"* ranging from red, thro the violets, over to and including some blues. Both acid colors and basic colors are found among the azines.

The *basic* members include spirit Indulines, Safranines, and Rhodulines. Perkin's Mauve or Mauveine the first aniline color, belongs to this group. It is not much used at present, however.

The *acid* members among the azines include Nigrosines, Soluble Indulines, Rosindulines, Wool Fast Blue, and Wool Fast Violet; also a spirit-soluble Nigrosine, and an acid water-soluble Nigrosine with various brands of each on the market. The spirit-soluble Nigrosine is used in black spirit-varnishes and polishes, and also for a dye for coloring silk. It gives a bluish-black, and is used much like the spirit-soluble Induline, except that the latter produces a more bluish-violet tone. There is also an acid water-soluble Induline that is quite fast to light. The Indulines are often mixed with other colors of similar application classes.

The acid water-soluble Nigrosines are often used in connection with other acid dyes to secure darker colors. They are sometimes found in stains for wood and dyes for silk. They are, however, only moderately fast to light. Various brands of this color are sold, but they are all similar to Shultz's Nigrosine No. 700.

Spirit-soluble Nigrosines, which are soluble in alcohol but not in water, are used in spirit-stains for wood, for darkening other colors. These Nigrosines are also used in polishes, black spirit-varnishes, for staining leather, for printing calico and dyeing silk, and produce bluish-black shades. They are often mixed with Chrysoidine R (spirit-soluble), which is of a yellowish-red color. The various brands of spirit-soluble Nigrosines which are sold are similar to Shultz's No. 698.

100. Xanthene Colors.—These colors form a group containing some of the most brilliant acid and basic dyes made, and are, in general, faster to light than the triphenylmethane colors, already mentioned.

101. Anthracene or Anthraquinone Dyes.—This large group contains 67 acid and mordant dyes, and includes the alizarines and 82 vat dyes. These colors are, in general, remarkable for great fastness to light. The anthraquinone class does not include any basic colors.

The "acid" colors of the group are numerous and important, and include: Alizarine Direct Blue, Violet, and Green; Alizarine Sapphire, a reddish-blue dye which is very fast to light; the German dyes, Alizarine Irisol D and R, bright bluish-violet wool and silk dyes, which are very fast to light; Alizarine Emeraldol G (paste), a bluish-green dye for wool and silk, moderately fast to light; Alizarine Astrol B and G, greenish blue, and very fast to light on wool and cotton; and the Alizarine Rubinols, some of which are of a bluish-red color and fast to light, while others are pink and salmon in hue and are used on dress-goods and carpets.

102. Nitroso and Nitro Dyes.—The nitroso colors are few in number and contain only "acid" and "mordant" dyes.

The important acid water-soluble dye in the Nitroso group is often called Naphthol Green B. It comes in powder or paste form, is very fast to light, and is used as a wool dye, the coloring-matter being used in an acid bath containing an iron salt. Naphthol Green is also used in the manufacture of pigments. This color is a very useful yellowish-green dye, recommended as a stain for wood-finishing because of its light-proof qualities.

The *Nitro* class is also small, containing several yellow acid dyes and a few mordant and pigment colors.

The most important "acid" member of this class is generally named Naphthol Yellow S, but is sometimes called Sulphur Yellow S, Acid Yellow, or Martius Yellow. It is used as a yellow color for silks and wool, and also is permitted as coloring-matter in food in Australia and the United States. Victoria Yellow, and Picric Acid also belong to this group.

103. Oxazine Colors.—This group contains about 44 dyes, and includes both basic and mordant colors but no acid dyestuffs. The colors are largely blue, Meldola's Blue or New Blue R being the most important.

104. Acridine Colors.—The Acridine colors are about 15 in number, and consist of yellow and orange dyestuffs, all of which are basic dyes. They are only moderately fast to light, ranking, usually about 3 or 4 in the scale of 5 for fastness. Their chief uses are in dyeing leather and cotton, and in printing calico.

105. Thiazine Colors.—This group consists of about 13 dyestuffs, mainly blue in color. It has representatives among the basic, acid, mordant, and sulphur dyes.

Basic colors. The most important dye among the Thiazines is the basic dye, Methylene Blue, which is high in fastness to light, ranking 2 in the scale of 5 degrees, of which 1 is the most permanent of all. Methylene Blue is soluble in both water and alcohol. It is recommended as an excellent basic dye for wood-staining on account of its fastness to light. It is also commonly used for dyeing cotton in half-silk, jute, straw, and artificial flowers. On account of its excellent fastness to light, to washing and rubbing, to ironing, to water, and to acids, it is one of the most largely used of all the basic dyes.

Other important Thiazine basic colors are: Methylene Green, which ranks as the fastest of all of the basic green coloring-matters, and Thionine Blue, also quite fast and soluble in both water and alcohol, altho less easily soluble in the latter.

Acid color. Thiocarmine is the acid member of the Thiazine class, and is a good blue for wool and silk. It is not so fast to light as Patent Blue or Cyanol.

106. Thiazole Colors.—This class includes a small group of six distinct colors, some of them having numerous names. There is one basic dye—Rhoduline Yellow T, or Thioflavine T—which is a moderately fast dye, grading 3 in the scale of five degrees.

107. Quinoline Colors.—The quinolines form a small group of 12 colors, only three of them being manufactured in the United States. These dyes are largely used in the manufacture of the color-sensitive plates. The most important member of the group from a dyer's standpoint is Quinoline Yellow, which is a basic dye and insoluble in water, tho sparingly soluble in alcohol. It is a yellow, and is used to color paraffine, wax, and spirit-varnishes.

From Quinoline Yellow, treated with fuming sulphuric acid, an acid dye soluble in water called Quinoline Yellow O is made.

Most of the other Quinoline colors are quite fugitive, and are unsuitable for use as stains for wood.

108. Indigoid Colors.—This group contains 54 colors, including a number of valuable "vat" dyes. There are no basic or mordant colors listed in this class, and only one acid dye—Indigo Carmine—which is not much used, because it is not fast to light and has been replaced by Patent Blue.

COAL-TAR DYES CLASSIFIED BY APPLICATION

The average user of dyes does not understand the chemical structure of dyes which are made from the rather simple hydrocarbons, such as benzene (C_6H_6), toluene (C_7H_8) xylene (C_8H_{10}), naphthalene ($C_{10}H_8$), and anthracene ($C_{14}H_{10}$). If, however, dyes are classed together on a basis of methods of application to various fibers, and of affinity for and reaction on the fibers themselves, it is easier to grasp the significance of such a grouping.

It is of interest to the wood-finisher to examine a list of the application classes which are known to the textile dyer. It should be remembered, however, that some colors can be placed in two or more classes, and applied by more than one method. This may be due to the peculiar chemical composition of the dyes which can be classified in more than one group, or to certain chemical or physical properties of the fibers of the materials. The application classification of dyes is as follows:

1. Acid dyes.
2. Basic dyes.
3. Salt, direct, or substantive dyes.
4. Mordant dyes.
5. Pigment dyes.
6. Developing colors.
7. Sulphur colors.
8. Vat dyes.

109. Acid Dyes.—In general, acid dyes are very largely derived from azo compounds of toluene and benzene, both of which come from light-tar-oils. These dyes are said to be salts of color-acids which are easily soluble in water. Most of the acid dyes require the presence in the bath of some acid which liberates the color-acid, and thus allows it to combine with bases which are found in the fibers being dyed, usually animal fibers, such as silk and wool. On these materials, acid dyes act as direct dyes, and need no mordant. Many acid dyes do not dye vegetable fibers, therefore they are not much used for dyeing cotton-goods. It should be pointed out very clearly, however, that, altho pure cellulose does not usually take acid dyes, lignocellulose, such as is found in jute and wood, will combine directly with acid dyes.

The azo acid group is a large one, and contains many yellows, oranges, scarlets, blacks, etc. There is also a small class of yellow dyes, the most important member of which is Naphthol Yellow S, which is derived from nitro compounds.

Individual acid dyes vary considerably in fastness to light. In general, the azo dyes are quite permanent, while acid violets and greens, usually, are more fugitive. Some acid dyes are not entirely satisfactory on textiles, because they will not stand washing, especially if soap is used. On wood, however, these same dyes give no trouble, because the colors are fast to light, and are usually protected by varnish coats.

The acid colors do not usually show an acid reaction in themselves, but are sold in powders of alkaline salts of potassium or ammonium which are soluble in water. The neutral or alkaline powders of acid dyes are acidified in the solution, usually with sulphuric acid, for dyeing wool or silk. The acid reacts on the dyestuff in such a way as to set free the color-acid, and also to change the composition of the fibers to be dyed and leave them in the proper condition to receive the dye.

Sometimes acetic or formic acid, or even ammonium acetate, is used as a substitute for sulphuric acid; in which case the dye is only slightly acid in reaction.

There is also a third class of acid dyes which will dye some fibers in a neutral bath. When acid dyes are used as wood-stains, it is not usually necessary to add any acid whatever to the stain, because wood fibers generally react properly with such dyes and take the color easily. Many acid coal-tar stains when used on wood ''bite'' more easily, however, if one-half pint of table vinegar be added to each gallon of stain.

Acid dye-powders are soluble in water. They usually dissolve better in hot water, and are frequently prepared in this manner as less residue is left. A few acid dyes, such as Metanil Yellow, Orange II, Violamine RR, are somewhat soluble in alcohol.

Acid dyes are usually quite cheap, compared with other coloring-materials, and the tones produced on most substances are pure and brilliant. In the latter respect, acid dyes are generally superior to both mordant and substantive dyes, but are not equal to basic dyes.

Wood-stains for use on furniture are at present very largely made from acid coal-tar dyes. See Table I.

110. Basic Dyes. — The characteristics and physical properties of basic dyes soon become known to the dyer, but the name itself may not mean much to him. To the chemist, however, the word basic is suggestive, because it indicates something of chemical structure and informs him as to the dye's reactions, with such reagents as acids and alkalies particularly. See Table II. Basic colors are substances that have strong affinities for various acids and with them form salts that are more or less stable. Liberation from the salts can be secured by the use of the volatile alkali, ammonia, or by reactions with fixed alkalines, such as soda and potash, which have strong basic action.

In chemistry, the word base refers to substances that are capable of uniting with acids, thus producing salts which are neutralized of acid properties.

The most important basic dyes are derived from triphenylmethane; nevertheless, some valuable basic dyes come from various other chemical classes, such as the azos, xanthenes, azines, acridines, thiazines, and thiazoles. Less valuable basic dyes, from the dyer's point of view, are made from the oxazine and quinoline groups.

A large number of the early aniline and other coal-tar dyes belonged to the basic group of dyestuffs. In many cases, these basic dyes are very remarkable for brilliancy of color, compared with vegetable colors; but, quite often, they are more or less fugitive to light. Basic dyes sold on the market are usually in forms which are chemically known as chlorides, being salts of dye bases with hydrochloric acid, but other salts such as sulphates, oxalates, acetates, and nitrates, are occasionally found.[5] Dyes in the form of a free base are known, however, in a few cases. Methyl Violet, Magenta, and some other colors made by the "melt" process, are in a crystalline form; while most

---

[5] See J. M. Matthews, *The Application of Dyestuffs*, p. 247.

TABLE I.

ACID DYES USED FOR WOOD-STAINS. SOLUBLE IN WATER

Color	Shultz No.	Name of Color	Fastness to Light	Chemical Group	Maker
Red	227	Croceine Scarlet	2	Dis-Azo	DuPont
Red	42	Pontacyl Carmine 2G	2–3	Mono-Azo	DuPont
Red		Pontacyl Carmine 2B	2–1	Mono-Azo	DuPont
Red	163	Pontacyl Ruby G	2–1	Mono-Azo	DuPont
Red	161	Pontacyl Fast Red AS	4–3	Mono-Azo	DuPont
Red	82	Acid Scarlet 2R	3	Mono-Azo	Newport Chem. Wks.
Red	163	Azo Rubine R	2–1	Mono-Azo	Newport Chem. Wks.
Red	227	Croceine Scarlet MOO	2	Dis-Azo	Newport Chem. Wks.
Red	163	Azo-Rubine Ex	2–1	Mono-Azo	National Aniline and Chem. Co.
Red	169	Brilliant Scarlet 3R	2–3	Mono-Azo	National Aniline and Chem. Co.
Red	227	Croceine Scarlet MOO	2	Dis-Azo	National Aniline and Chem. Co.
Orange	145	Orange II	3–2	Mono-Azo	DuPont
Orange	145	Orange II conc.	3–2	Mono-Azo	DuPont
Orange	38	Orange G	2–3	Mono-Azo	DuPont
Orange	145	Orange A	3–2	Mono-Azo	Newport Chem. Wks.
Orange	145	Wool Orange A	3–2	Mono-Azo	National Aniline and Chem. Co.
Yellow	23	Tartrazine O	Moderate on Wool, Low on Silk	Azo	DuPont
Yellow	134	Metanil Yellow conc.	3	Mono-Azo	DuPont
Yellow	19	Pontacyl Yellow GG (same as fast light yellow)	2	Azo	DuPont
Yellow	19	Pontacyl Yellow 3G	2	Azo	DuPont
Yellow	23	Fast Wool Yellow G	Moderate on Wool, Low on Silk	Azo	Newport Chem. Wks.

TABLE I.—Continued

ACID DYES USED FOR WOOD-STAINS. SOLUBLE IN WATER

Color	Shultz No.	Name of Color	Fastness to Light	Chemical Group	Maker
Green					
Sea Green	566	Pontacyl Green SN extra	3	Triphenylmethane	DuPont
Light Green	505	Pontacyl Light Green SF, yellowish	4	Triphenylmethane	DuPont
Green	502	Acid Green B conc.	4–3	Triphenylmethane	Newport Chem. Wks.
Green	503	Fast Milling Green B	3–4	Triphenylmethane	Newport Chem. Wks.
Yellowish Green	4	Naphthol Green	1	Nitroso	Newport Chem. Wks.
Blue					
Greenish Blue	545	Pontacyl Brilliant Blue A	3	Triphenylmethane	DuPont
Blue	545	Patent Blue A	3	Triphenylmethane	Newport Chem. Wks.
Blackish Blue	217	Acid Blue Black, extra conc.	2–3	Dis-Azo	Newport Chem. Wks.
Violet	582	Violamine RR (Reddish violet)	2–3	Xanthene	DuPont
Bluish Violet	530	Acid Violet 5B conc.		Triphenylmethane	Newport Chem. Wks.
Black					
Bluish Black	700	Nigrosine WSB powder	4–3	Azine	DuPont
Black	700	Nigrosine jet	4–3	Azine	Newport Chem. Wks.
Bluish shade	700	Nigrosine, blue shade	4–3	Azine	Newport Chem. Wks.
Black	700	Nigrosine 128 conc.	4–3	Azine	National Aniline and Chem. Co.

TABLE II.

BASIC DYES

SOLUBLE IN WATER OR ALCOHOL

(Palette containing some of the best basic colors for staining wood)

Color	Shultz No.	Name of Color	Fastness to Light	Chemical Group	Maker
Red	573	Rhodamine B	3–4	Xanthene	DuPont
Red	679	Safranine T extra	3–5	Azine	DuPont
Red	679	Safranine Y	3–5	Azine	Newport Chem. Works
Red	512	Fuchsine or Magenta	4–5	Triphenylmethane	Newport Chem. Works
Orange	33	Chrysoidine GE	4	Mono-Azo	DuPont
Orange	34	Chrysoidine R		Mono-Azo	Newport Chem. Works and DuPont
Yellow	493	Auramine O	4–5	Ketonimine related to Triphenylmethane	Newport Chem. Works and DuPont
Yellow	618	Thioflavin T	3	Thiazole	Newport Chem. Works
Green	499	Brilliant Green Crystals	3–4	Triphenylmethane	Newport Chem. Works
Green	495	Malachite Green Crystals	3–4	Triphenylmethane	Newport Chem. Works
Green	495	Victoria Green SC	3–4	Triphenylmethane	Dupont (same as Malachite Green)
Green	*924	Methylene Green	Very fast	Thiazine	Various manufacturers
Blue	659	Methylene Blue, extra conc.	2	Thiazine	Newport or DuPont

*No. 924 for Methylene Green is a *"Color Index"* number instead of a Shultz number.

TABLE II.—Continued

BASIC DYES

SOLUBLE IN WATER OR ALCOHOL

(Palette containing some of the best basic colors for staining wood)

Color	Shultz No.	Name of Color	Fastness to Light	Chemical Group	Maker
Blue	559	Victoria Blue BX	4–5	Triphenylmethane	DuPont
Blue	558	Victoria Blue R	4–5	Triphenylmethane	DuPont
Violet	515	Methyl Violet R conc.	4–5	Triphenylmethane	DuPont or Newport Chem. Works
Brown	284	Bismarck Brown R Base	4–5	Dis-Azo	Newport Chem. Wks.
Brown	283	Bismarck Brown G or Y	4–5	Dis-Azo	Newport Chem. Wks.
Brown	283	Basic Brown G	4–5	Dis-Azo (Mahogany wood Stain)	
Brown	284	Basic Brown BR	4	Dis-Azo (Mahogany wood Stain)	DuPont (same as Bismarck Brown)
Brown	283	Bismarck Brown Y ex.	4–5	Dis-Azo (Mahogany wood Stain)	DuPont (Bismarck Brown)
Brown		Nat. Bismarck Brown 53			Nat. Aniline and Chem. Co. Nat. Aniline and Chem. Co.
Black		Nigrosine			Various manufacturers

of the basic dyes manufactured by other methods are in the form of powders.

In a dye-bath, basic salts seem to separate into an acid and a dye-base. When dyeing animal fibers, such as wool or silk which seem to possess acid properties in themselves, the dye-base combines with the fibers, and acid is left in the bath. When cotton is dyed with these dyes the dye-base combines with the acid mordant. Cotton requires a previous preparation in a tannic-acid bath, called a mordant.

Mordanting of vegetable fibers, such as cotton and linen, is accomplished by steeping the material to be dyed in a cold tannin bath for several hours, and fixing in a tartar emetic; or following this treatment by passing the goods being dyed thro a solution of some metallic salt, such as antimony potassium tartrate. Insoluble tannates of antimony or some other metal are finally formed.

Wool and silk because of their acid reaction are dyed with basic dyes in a neutral bath without previous treatment. Brighter colors in wool and silk fabrics are sometimes secured from basic dyes by adding about two per cent of soap to the dye-bath.

Basic dyes are not as valuable to the dyer of textile fibers as formerly, because we now have other dyes of greater fastness that can be applied by easier methods. Cotton and linen fabrics which have been dyed with "salt" or "sulphur" colors are often improved by "topping" or redyeing with basic colors. This application of basic dyes increases the fastness to light of "salt" colors, and produces more brilliant tones over "sulphur" colors. No mordant is needed for "topping" fibers with basic dyes, because the previous dyeing serves as a mordanting where "salt" mordant or "sulphur" colors have been used.

For wool and silk, basic dyes have very largely been replaced by more permanent and easily applied but less brilliant acid dyes which are more numerous and produce more even tones.

For bark-tanned leather which contains much tannic acid, basic colors are recommended, because the leather absorbs these dyes easily, and evenness of tone and fastness to light are not so important.

Wood-stains which are produced by dissolving basic dyes in water or alcohol are used by the wood-finisher to a limited extent. The colors obtained by the application of basic dyes to wood are clear and brilliant; but, in many cases, beautiful tone effects are changed and faded by exposure to light. It has already been pointed out that a mordant is used with basic dyes when they are used on vegetable fibers. The wood-finisher does not wish to spend his time using mordants on stains, therefore he prefers the more convenient and more permanent acid dyes.

Spirit-stains are made from the most permanent of the basic dyes, and are used with reasonable satisfaction on articles that are not exposed to bright sunlight. Mordants are not commonly used with spirit-stains. Such stains dry very quickly, and are very hard to apply.

111. Salt, Direct, or Substantive Dyes.—The name "direct" colors is given to this particular class of dyestuffs because they really are direct dyes for cotton when used in a neutral or alkaline bath, and are applied without the use of mordants.

The "direct" colors are sometimes called substantive colors, and also occasionally are referred to by other names, such as Congo colors, diamine colors, and benzo colors. Most of the direct colors are alkaline salts of sulfonated tetrazo colors.

Salt or direct dyes may be used in a hot neutral or alkaline bath for dyeing silk or wool, and also in an "acid" solution. Direct dyes are, however, rarely used for dyeing animal fibers.

Direct colors are absorbed without being broken up, or having only the color-acid taken out, as is the case with acid-dyes. The salt or direct colors are ordinarily used in a bath of boiling water to which common table salt and soap have been added, and are adapted to coloring such fibers as cotton and linen.[6] Some fibers, especially cotton, linen, and other vegetable fibers, will take direct dyes in a cold or lukewarm bath, but such dyeing will not stand hot soap and water.

More permanent colors can be produced with direct dyes by the use of a suitable after-treatment, such as warming in a weak solution of potassium bichromate which is acidified slightly with acetic acid or strong vinegar. This treatment may considerably change the color and is sometimes objectionable.

The salt or direct colors come from two of the chemical groups, namely: (1) the thiazols and (2) the azo colors.[7]

The direct colors are soluble in water, and in general may be used much like acid dyes; they are useful, especially, on cotton and linen, while acid dyes in general will not color cotton or many vegetable fibers. Some of the direct colors are recommended for cotton, straw, wood chips, paper, linen, jute, and vegetable fibers in general. On wood they are not as convenient and satisfactory as acid dyes, and should generally contain one ounce of bichromate of potash to the gallon of stain.

In fastness to light the direct dyes are very satisfactory, especially, when given an after-treatment of bichromate of potash.

Direct dyes can often be mixed with acid dyes in making wood-stains. Experts, however, recommend keeping the application classes separate for fear of a chemical reaction. It should also be noted that direct dyes are improved usually by having potassium bichromate in the dye solution or for use as an after-treatment, while acid dyes are commonly used with a small amount of acid, such as acetic acid, in the stain mixture. It has already been pointed out that such a mixture of an alkali and acid may change the color of a direct dye.

---

[6] See Charles E. Pellew, *Dyes and Dyeing*, pp. 62, 63.

[7] See Arthur G. Green, *Analysis of Dyestuffs*, Table I, p. 40.

112. Mordant Dyes.—Many of the old-time vegetable dyes such as logwood, fustic, cutch, Persian berries, and the animal dye cochineal, are mordant dyes. It is also true that many of the best of the synthetic or coal-tar colors are mordant dyes. Treatment with metallic mordants in connection with the dye, but usually preceding it in application, is necessary with mordant dyes. The use of different mordants with a given color may produce varying shades of color, or even change the hue itself. Salts of chromium, such as chromates or bichromates, are now most commonly used; while formerly, tin, iron, and aluminum salts were generally used.

Mordant dyes are used on both cotton and woolen fabrics. A few mordant dyes produce color in a single bath containing a bichromate or chromate solution; but, usually, two or more operations are necessary, therefore exact reproduction of colors is difficult, and the many operations are expensive.

Several of the chemical groups of dyes contain mordant dyes, as indicated by the following list: nitroso, nitro, azo, triphenylmethane, xanthene, anthracene, oxazine, thiazine, and flavone—all including one or more mordant dyes.

On account of their difficulty in application, mordant dyes are not very commonly used as wood-stains at the present time. The vegetable mordant dyes, which for many ages were generally thought to be the only satisfactory dyes, are gradually going out of use; and, judging by the demand for them on the market, it might be said that they are not of much importance to the wood-finisher today.

113. Pigment Dyes.—Certain colors which are insoluble in water and in most solvents can be transferred to fibers by a method of chemical synthesis. Such colors are very fast to light and washing, and are not easily removed from the fibers. Aniline black can be made to dye cotton fiber by means of the oxidation of salts of aniline when bichromates or chromates are used in connection with certain so-called oxygen carriers, such as some of the salts of iron, vanadium, or copper. Other semioxidation colors are the Ursols, the Furols, and Paramine Brown.

Pigment-dyes are derived from four of the chemical groups as follows: the azo, the nitro, the azine (which contains Aniline Black), and the oxazine classes.

In dyeing, the pigment colors are transferred to the fibers being dyed by a chemical synthesis and from colorless chemical compounds.

114. Developing Dyes.—The developing colors resemble the pigment-colors in that they are both insoluble and must be transferred and formed on the films of the material being dyed. The developing colors are not colorless dyestuffs, but react differently from ordinary dyes because a chemical reaction causes a coloring-matter to be developed and formed on the fibers.

115. Sulphur Dyes.—These colors are also insoluble in pure water; but, if they are dissolved in an aqueous solution of sodium sulphide and heated, they will dye vegetable fibers, especially cotton, in a direct bath. These colors are little used on animal fibers. The resultant hues produced on fabrics are not bright, but appear as dull shades of green, brown, blue, and black.

These dyes contain sulphur in the molecules, but their structure is rather indefinite.

Sulphur dyes are considerably used, however, for dyeing cotton cloth, and also for yarns and hosiery.

An after-treatment with a salt of copper, zinc, or chromium is sometimes used to "fix" the sulphide colors.

116. Vat Dyes.—The term vat dyes is used to designate certain dyestuffs that are themselves insoluble in water but which can be used in the form of their leuco compounds and then oxidized in the air, thus bringing out the colors. A leuco compound in chemistry is one that is colorless and is derived from a dye by reduction, having an unsatisfied affinity for nitrogen. By oxidation or the taking on of oxygen, leuco compounds regain color.

TABLE III.

Oil-Soluble Dyes Used for Staining Wood
Soluble in Turpentine, Benzol, or Naphtha

Color	Shultz No.	Name of Color	Fastness to Light	Chemical Group	Solvent	Maker
Red	76	Spirit Scarlet B extra	...	Mono-Azo	Alcohol and Oils	DuPont
Red	76	Oil Red O	...	Mono-Azo	Benzol, Naphtha	Nat. Aniline & Chem. Co.
Red	...	Oil Scarlet 6 G	...	Used as a furniture stain	Benzol or Naphtha	Nat. Aniline & Chem. Co.
Red	93	Sudan R	Good	Mono-Azo	Alcohol, Benzol, etc.	Newport Chem. Wks.
Red	232	Newport Oil Red No. 13044	2–3	Dis-Azo	Alcohol Benzol	Newport Chem. Wks.
Orange	36	Oil Orange No. 2311	...	Mono-Azo	Benzol or Naphtha	Nat. Aniline & Chem. Co.
Orange	36	Newport Oil Orange, extra conc.	...	Mono-Azo	Alcohol and Oils	Newport Chem. Wks.
Yellow	68	Oil Yellow No. 2681	...	Mono-Azo	Benzol or Naphtha	Nat. Aniline & Chem. Co.
Yellow	68	Oil Yellow	...	Mono-Azo	Alcohol and Oils	DuPont
Yellow	32	Newport Oil Yellow	...	....	Alcohol, Benzol, and other oils	Newport Chem. Wks.
Blue	559	Newport Victoria Blue	4–5	Triphenylmethane	Alcohol, Benzol, and other oils	Newport Chem. Wks.
Black	990	Drop Black	...	Mineral Pigment	Turpentine	Various (This is not a coal-tar dye)
Black	...	National Oil Black Jet shade	...	....	Turpentine	Nat. Aniline & Chem. Co.
Black	...	National Oil Black Blue shade	...	....	Turpentine	Nat. Aniline & Chem. Co.
Brown	...	Oil Brown M	...	Mahogany brown Wood Stain	Alcohol, Benzol, or Naphtha	Nat. Aniline & Chem. Co.

For many years indigo was the chief vat dye, but at the present time other indigoid vat dyes are used, such as the Ciba series, the Bromindigos, the Thioindigo series, and Brilliant Indigos. There are also anthracene and thiazine vat dyes.

117. Oil-Soluble Wood-Stains.—Oil-soluble dyes do not form a distinct class of colors either chemically or by application. Colors from any of the various coal-tar groups that happen to be soluble in any one of the volatile oils are selected, especially the kinds that are most permanent on exposure to sunlight.

Some of the best oil-soluble dyes for use as stains on wood are given in Table III. A few others are found in the following list:

Red—Bismarck Brown, Carmosine, and Oil Scarlet 6 G.
Orange—Oil Orange G, and Oil Orange Y (extra concentrated).
Yellow—Oil Yellow, Auramine Yellow, and Naphthalene Yellow.
Green—A mixture of yellow and blue.
Blue—Victoria Blue.
Brown—Oil Brown M, Loutre, and Seal Brown.
Brown Mahogany—Orange G or Y, and Naphthalene Black, or Oil Brown M.
Black—Oil Black, oil-soluble Nigrosine, and Naphthalene.

Oil-soluble colors are usually dissolved in turpentine, but benzene or benzol, naphtha, gasoline, and carbon tetrachloride, can also be used as solvents for nearly all such colors.

118. Classes of Dyes Used in Wood-Finishing.—Most of the books and magazine articles which have been written about dyes have been produced for the textile colorist or dyer, rather than for the person who wishes to use dyes for the purpose of staining wood. The dyes themselves were usually manufactured for dyeing cloth rather than for staining wood; consequently the characteristics of the various dyes are usually given with reference to their reaction on various kinds of cloth fibers.

Acid coal-tar dyes are used by the textile dyer to color fibers of silk and wool. Many of these acid dyes will not color cotton fibers, but they will easily stain the lignocellulose fibers which compose the chief mass of wood substance.[8] Practically any of the acid coal-tar dyes which are ordinarily used for dyeing silk and wool can be considered as satisfactory stains for wood. Dyes for cloth must prove satisfactory in various tests such as fastness to light, fastness to washing, fastness to milling, and also to "stoving," to crocking, or rubbing.

In selecting an acid coal-tar dye for use as a wood-stain the chief considerations are fastness to light and the price of the dyestuff. The best of the acid coal-tar dyes are the most light-proof colors that can be obtained and are now used extensively as wood-stains.

Acid dyes can usually be mixed together to form new colors, even tho the individual dyes may come from different chemical groups. Acid dyes should not be mixed with basic colors, even tho the latter may be soluble in water, nor should either of these groups of stains be combined with spirit-soluble or oil-soluble dyes.

Acid dyes are not usually acid in reaction but are alkaline salts of sodium, potassium, or ammonium. Basic dyes are usually chlorides, but occasionally other salts such as sulphates, olalates, acetates, or nitrates are found. If an acid dye in a solution of water is mixed with a basic dye in an aqueous solution, a chemical reaction may take place, and a new substance which is soluble in water may be formed. In some cases a compound neutral dye may be produced.

Direct or salt dyes can be used in much the same manner as acid dyes for staining wood. In fact, direct colors can often be mixed with acid colors in preparing wood-stains. The mixing of colors from the different application classes involves a greater risk, however, and is not recommended.

Basic dyes when used by the textile-dyer are dissolved in water, are often used on cotton, and are "fixed" with a mordant. Basic dyes are generally soluble in alcohol, and are the colors used by a wood-finisher when he wishes spirit-soluble colors. In general, basic colors are more fugitive than acid coal-tar dye colors, hence they are not as satisfactory for use in stains for wood.

---

[8] See A. C. Newell, *Wood and Lumber*, pp. 73, 74.

Dyestuffs taken from the other application classes, while useful and practicable as textile-dyes, are rarely used on wood because of the difficulty in application to such material. In other words, mordant dyes, pigment dyes, developing colors, sulphur colors, and vat dyes are not in common use by wood-finishers, tho they are valuable textile dyes.

119. Dyeing or Coloring Wood.—Dyeing a piece of wood, in the true sense, consists in steeping it in a solution of dye, and giving it treatments similar to those used in dyeing textiles, straw, and the like, in which the color penetrates entirely thru the wood mass and changes the hue of all the fibers. Rather large pieces of wood are sometimes stained or dyed to a uniform color thruout the interior instead of on the surface only. This can be done by removing the air in the cells, by placing the piece in a vacuum chamber, and then immersing it in a dye liquid under pressure of 80 to 120 atmospheres in a large tank. This procedure is useful for some purposes, but is not the most common method of coloring or staining wood.

Staining or coloring wood is usually done by brush (or sometimes sponge) applications, by spraying with an air gun, or by dipping and wiping. This method of staining the surface, or dyeing, as it is sometimes called, changes the color only superficially, because the dye does not penetrate very deeply into the wood mass.

Plaits, strips, chips, small blocks, and sometimes match-sticks, are dyed by the first method of uniform penetration, but furniture and woodwork in general are treated by the superficial methods of brushing, spraying, or dipping.

The dyes used for such staining are acid dyes, basic dyes, or substantive dyes that are quite fast to light and which are soluble in water. Basic dyes are soluble in either water or alcohol. Some dyes that are useless for dyeing textiles, because they are insoluble in water, are soluble in alcohol, and can be used as spirit-stains for wood. Spirit-soluble dyes are also used in varnishes. There are also dyes that are insoluble in water but which are oil-soluble, and can be dissolved in benzene or benzol, gasoline, kerosene, or carbon tetrachloride.

For the coloring of raffia, straw, wood chips, splints, and other similar materials frequently used in the manufacture of hats and baskets, basic coal-tar dyes of the most permanent kinds are much desired because of their brightness. There is usually enough tannic acid in most of the above materials, and also in jute and many kinds of wood, so that basic dyes can be used directly; that is, without the application of any other mordant than that already possessed by the fibers themselves.

120. Solubility of Dyestuffs and Wood-Staining Materials.—Coloring-matter intended for use in textile-dyeing and wood-staining is found on the market in one of three forms: (1) as a powder, (2) as a paste, and (3) as an extract. The powder form, very commonly used for textile-dyes and wood-stains, is the most difficult to dissolve. The different classes of dyestuffs, and the individual colors in the groups, vary greatly in their solubility.

121. Water-Soluble Colors.—Dyestuffs of the usual solubility, when being prepared as wood-stains, are generally dissolved in the proportion of about 3 to 3¼ ounces of powder to the gallon of soft water. Some of the dye-powders of low solubility are used in wood-stains in the proportion of one ounce, or even less, to the gallon of water. Dyes for wood are, however, very strong in color, and often as much as six ounces of color in powder form are mixed with one gallon of water in order to secure the proper strength.

Dealers in dyes for wood-stains usually give instructions as to the amount of powder that should be used in the solvents, which are also named, as water, alcohol, benzol, turpentine, and others. It should be remembered, however, that straining a dye-mixture thru a cloth of fine mesh is generally advantageous, because this process removes specks and any undissolved powder that may settle to the bottom after the solution becomes cold.

The acid coal-tar dyes which are very often used in staining high-grade furniture are usually very soluble, which is also generally true of alcohol-soluble powders. The oil-soluble colors are often harder to dissolve. Hard water when used in dyeing textiles is generally acidulated slightly with acetic acid, using only enough acid in the bath to give an acid reaction with litmus paper. It is, however, preferable in some cases to add a small amount of sulphuric acid to the water instead of acetic acid. This hint on the use of acid with acid dyes in dyeing textiles may prove advantageous to wood-finishers in preparing acid water-soluble dyes for staining wood.

Water containing iron compounds should not be used in dye-baths or stains without first making tests, because chemical reactions of this metal or its salts are liable to change the dye-mixture itself in such a way that modified or duller colors may result. Salts of iron with alkali mordants were used as dyes by many ancient peoples, and are still of service in improved forms.

Most dyes, especially acid coal-tar dyes, are most satisfactorily dissolved by using boiling soft water.[9] The mixing should be done in vessels of glass, earthenware, or copper, but never in containers of tin, if acid is to be added to the solution, or if the dye itself has an acid reaction, because the iron which forms the body of all tin-plated sheet-metal may change the dye itself.

122. Spirit-Stains.—Basic dyes are usually soluble in either water or alcohol. If water is used many basic dyes, such as Malachite Green and Methyl Violet, should be mixed with a small quantity of cold water slightly acidulated with acetic acid, and after stirring well, the thin paste formed can be added to boiling soft water. Some basic dyes should not be mixed or used at higher temperatures than about 180° F. When using the dye Auramine the temperature should not exceed 170° F., or the coloring-matter may be decomposed or precipitated.[10] A small amount of denatured alcohol is sometimes used in a basic dye solution to help in dissolving the dye.

---

[9] See J. M. Matthews, *The Application of Dyestuffs*, p. 209.

Many basic dyes are not easily dissolved in water, and for this reason the dye should be filtered thru a flannel cloth, and any alkalinity of hard water should be neutralized with acetic acid to prevent the color-base from precipitating. Spirit wood-stains often consist of basic dye-powders dissolved in strong denatured alcohol. Such a stain is very volatile, and dries so rapidly that it is difficult to apply with a brush.[11]

123. Oil-Soluble Dyes.—Other solvents besides water and alcohol are sometimes used in making dyes and stains. Ether, benzene, various acids, alum, tannin reagents, ferric chloride, sodium carbonate, and other chemicals will dissolve certain dyestuffs. Stains which are commonly called penetrating stains, or volatile oil-stains, are made by dissolving in some oil solvent any of the coal-tar dyes that happen to be soluble in any of the nondrying oils of a very volatile nature.[12] The solvent oils which are used most commonly are turpentine, benzol, xylol, solvent naphtha, gasoline, kerosene, and carbon tetrachloride. The dyes that are soluble in these volatile oils are not taken from any particular chemical group. All such dyes are, however, free from the sulphonic acid groups. The sulphonic acid groups contain the radical SO_2OH.

The amount of dry powder used in oil-soluble coal-tar stains varies greatly with the depth or strength of color desired. For light or weak colors, about four ounces of powder to each gallon of solvent may be used, while very dark or strong stains may contain about 32 ounces of dry powder to the gallon of stain.

---

[10] Ibid., pp. 209, 250.
[11] See Chapter V, "Spirit-Stains," p. 59.
[12] See Section 27, "Volatile Oil-stains," p. 55.

REFERENCES—CHAPTER IX

DYES

Thomas Beacoll, F. Challenger, G. Martin, and H. J. S. Sands, *Dyestuffs and Coal-Tar Products* (Fourth Edition, Revised, 1926).

J. Gault Bearn, *The Chemistry of Paints, Pigments, and Varnishes,* Chapter XIII, "Reaction of Aniline Lakes," pp. 148-150.

Cain and Thorp, *Synthetic Dyestuffs,* Chapter I.

H. J. Conn, *Biological Stains.*

Thomas W. Delahanty, *The German Dyestuffs Industry,* No. 126, Miscellaneous Series, United States Department of Commerce, Bureau of Foreign and Domestic Commerce, 1924.

Arthur George Green, *Analysis of Dyestuffs,* Chapter I, II, III.

P. H. Groggins, *Aniline and Its Derivatives.*

A. A. Kelly, *The Expert Wood-Finisher,* "Equivalents of Water-Colors in Aniline Dyes," p. 117; "Aniline Dyes," pp. 92-96.

F. Maire, *Modern Wood-Finisher,* Chapter VII, "Aniline Stains," pp. 62-64.

Geoffrey Martin, *Modern Chemistry and Its Wonders,* Chapter XII, "The Romance of Coal-Tar," p. 272.

Geoffrey Martin, *Industrial and Manufacturing Chemistry,* Sections XII, XIII, XVIII.

J. Merritt Matthews, *Application of Dyestuffs,* "Historical," pp. 7-16; "Classification of Dyes," pp. 154-8; "Nomenclature," pp. 222-3-4.

A. B. Pattou and C. L. Vaughn, *Furniture, Furniture-Finishing, Decoration, and Patching,* p. 159.

Charles F. Pellew, *Dyes and Dyeing,* "Coal-Tar Dyes and Their Use," Chapters II, III, IV, V, VI, VII, VIII.

Horace C. Porter and C. G. Storm, *Coal-Tar Products,* Technical Paper No. 89, United States Department of the Interior, Bureau of Mines, 1916.

F. M. Rowe, *Color Index,* Published by The Society of Dyers and Colorists (English), D. Van Nostrand Co., N. Y., January, 1924. (Gives list and brief description of all known coloring-matters).

Walter K. Schmidt, *Problems of the Finishing-Room,* Chapters III, X, XXV, XXVII, XXXIX.

A. W. Schorger, *The Chemistry of Cellulose and Wood,* "Dyeing Wood," pp. 381-3.

R. Norris Schreve, "An Outline of the Dye Industry," Journal of Chemical Education, Vol. 3, November, 1926, pp. 1259-1270.

Thomas Edward Thorpe, *Dictionary of Applied Chemistry,* Vol. II, p. 574.

F. H. Thorpe, *Industrial Chemistry,* pp. 485-512.

F. N. Vanderwalker, *Wood-Finishing, Plain and Decorative,* "Aniline and Other Coal-Tar Stains," pp. 39-66.

CHAPTER X

WOOD-FILLERS

124. The Purpose of Fillers.—Wood-fillers are used to level the surface of wood by filling the open pores or cavities in the cells. Fillers plug up the cell lumina, or openings, and prevent moisture from entering or leaving the wood; and, if composed of hard material, they help to form firm, compact, and more rigid surfaces that are less easily dented, scratched, or crushed in by pressure in small spots. Stained fillers are sometimes used to show contrasts, as in golden oak; or, very light effects in the pores may be wanted, as in silver gray, in which finish the filler may be largely zinc white or a mixture of that substance with a silex paste. By plugging or filling the open cell cavities with non-absorbent material, a level surface is secured which will receive varnish coats and hold them on the surface, instead of allowing such finishes to sink unevenly into the wood. See Fig. 10.

The type of filler to be used in a given case depends largely upon the porosity and character of the surface of the wood. In general, non-porous, diffuse-porous, and ring-porous woods require somewhat different treatment in filling.[1]

A coarse filler is ordinarily needed only on woods that have large tracheal vessels which formerly served as the water courses for the upward moving sap of the growing tree. The other kinds of wood cells, except possibly the larger fiber tracheids which are found in some of the conifers, have small cell openings which can be sealed up with a liquid filler, because they do not require masses of coarse material such as are contained in paste fillers.[2]

---

[1] A. C. Newell, *Wood and Lumber,* Chapter III, "Wood Cells," pp. 28-48.

[2] Ibid., "Tracheal Vessels and Tracheids," pp. 34-36.

CLASSES OR TYPES OF FILLERS

There are three types of wood-fillers, as follows:

1. An absolutely *transparent* filler, which is used as a sizing on woods that have such small cell openings that they are invisible to the eye. Such woods do not need to have the pores plugged or filled full of coarse material, and may be sized by oiling or shellacking.

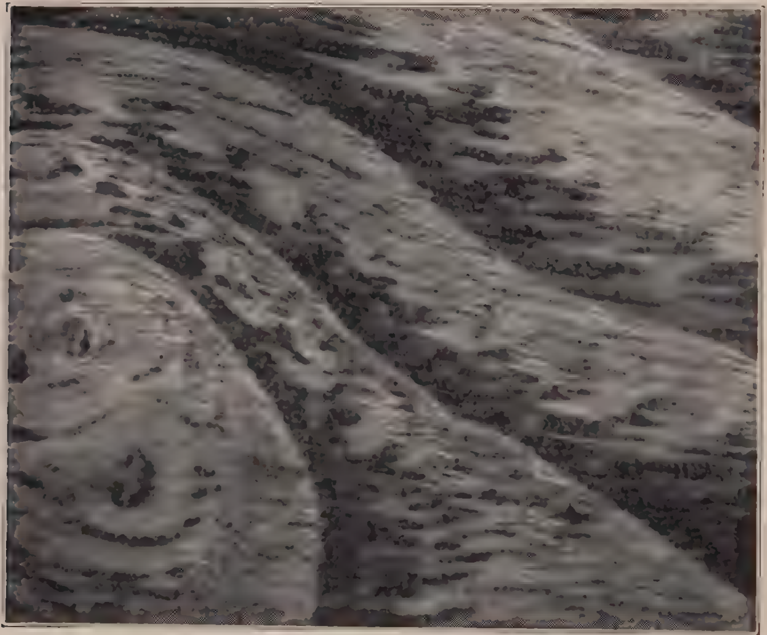


Fig. 10—Pores of Chestnut Wood Properly Filled
Magnification about 5 diameters.

2. A *liquid* filler, which is made of drying-oils, varnish, turpentine, japan, and a coarse material such as silica or some substitute, such as cornstarch, China clay, whiting, carbonate of magnesia, or talc. Such a filler is intended for use on nonporous or diffuse-porous woods with small cell openings.

3. *Paste* filler, which is usually made from a silex, or some other ground rock base, that furnishes coarse non-

shrinkable transparent material for plugging cell openings and leveling the long narrow hollow places or depressions that are left by cutting thru the tracheal vessels of ring-porous or coarse diffuse-porous woods.[3] In addition to the silex, paste filler contains drying-oils and some thinner or solvent that makes it easier in application with a brush to the surface of wood.

125. Transparent Fillers.—The time-honored process of filling wood was by applying many coats of some drying-oil, usually linseed-oil, rubbing, and allowing each coat to dry before another was applied. This method of filling the pores and protecting the wood was quite effective on all except possibly the coarse open-pored woods; but it was very slow, because such oils oxidize very slowly, and do not harden for a long time. Linseed-oil practically always darkens wood, and is objectionable on some light-colored woods; but it seems to enrich and bring out the grain and beauty of others, as is the case with walnut.

Shellac as a transparent wood-filler came into use later chronologically than linseed-oil. It is commonly used for this purpose on woods that have pores too small to be seen with the naked eye. Some of the close-grained hardwoods, and most of the coniferous woods, come under this classification, and can be sized or given a surfacer of thin shellac. Two thin coats are better than one heavy application.

Shellac is a spirit-varnish which is very transparent and dries hard in about 8 hours, instead of taking many days, as does linseed-oil.[4] It keeps the wood in almost the natural color, darkening it but little, and does not obscure the grain, as other fillers may do to some extent.

126. Liquid Fillers.—Certain surfacers on the market, called architectural fillers or liquid fillers, which are not much used in finishing furniture, are suitable to apply as a sizing material for a first coat on many of the rather soft, close-grained woods that have inconspicuous cell-openings.

---

[3] A. C. Newell, *Wood and Lumber*, "Tracheal Vessels and Tracheids," pp. 34-36.

[4] See Section 144, "Lac-Gum," p. 169.

Less labor is required in the application of this type of filler, because it is painted on much like a coat of varnish, and is not rubbed off. Liquid filler obscures the grain to some extent because the silex or coarse material, altho nearly transparent when mixed with linseed-oil, is stuck to the surface by varnish, instead of being left only to fill the large open pores, as is the case with paste fillers. Liquid fillers are quite commonly used on the less expensive soft woods, when a cheap finish is wanted. They are satisfactory as a first coat on many kinds of wood, especially in finishing the woodwork of houses; but they are not suitable to use on oak, ash, or other woods with large, conspicuous, open pores.

An experienced wood-finisher will usually make one gallon of liquid wood-filler cover about 250 square feet of surface.

The ingredients found in liquid fillers vary greatly, especially in the amount of silica (or silex) and varnish contained. Some liquid fillers are nearly pure varnish with the addition of small amounts of body materials, such as silica or whiting (calcium carbonate), together with some drier and thinner. Other liquid fillers are much like a thin paste filler, with only a small amount of varnish added to the mixture.

A filler having much varnish in its composition may be made up as follows:

1 quart varnish of good grade, as a rubbing-varnish.
1 pint light brown japan.
¼ to ½ pint turpentine.
1½ pounds light or floated silica (much less silica may be used).
Colors ground in oil may be added in small quantities.

The silica should be added last and mixed in gradually while stirring. Varnishes do not quickly assimilate a thinner, or mix with other substances; consequently, the above liquid filler should stand for one or two days, then should be stirred again and thinned until it will work freely with a stiff varnish-brush. It will spread on the wood more smoothly if strained thru cheese-cloth and allowed to stand another day or two before being used. The base or coarse materials are apt to settle, therefore the mixture should be stirred often while being applied.

A liquid filler with less varnish in proportion to the other ingredients may be mixed as follows:

1 quart body varnish, such as a rubbing-varnish.
1 quart brown japan.
2 pounds fine silex.

Thin slightly with turpentine, if necessary, to make it spread better with a stiff brush.

A liquid filler of the thinned-paste type may be made up as follows:

2 lbs. prepared paste filler.
½ pint turpentine.
⅛ pint rubbing-varnish.

The mixture should be put together in the order named, and may be thinned further with turpentine or benzine if it is to be used on close-grained, non-absorptive woods. A small amount of any of the colors ground in oil may be added to tint the filler to the proper color. A thin paste filler which contains no varnish can be used for a cheap finish on coarse-grained woods, such as oak and ash.

Liquid fillers are applied to wood evenly lengthwise of the grain, as in varnishing; and without being rubbed off, if they contain much varnish, they should be allowed to dry. They should then be smoothed with No. 00 or No. 000 sandpaper before the next coat of finish is applied.

The prepared liquid fillers sold on the market are usually made from valuable formulas, and by experienced men who have good equipment; therefore, they are, in general, more satisfactory than mixtures prepared by the ordinary wood-finisher. Nearly all small shops buy ready-mixed fillers, which are usually put up in cans of various sizes.

PASTE FILLERS

127. Body Materials in Fillers. — Furniture-finishers usually prefer paste fillers. Liquid fillers act as sizing, and stop the suction of the cavities of the wood cells, or greatly reduce it, at least; but, when used on ring-porous woods, like oak, ash, or chestnut, such mixtures are too thin to fill completely the large open tracheal vessels located in the spring wood of each annual layer of growth. Some method of filling these open pores and leveling the surface must be used if a good finish is to be secured. Many coats of liquid surfacer can be applied with quite satisfactory results, provided all the high spots are cut down with fine sandpaper between applications of the finish. The open pores or cell cavities gradually fill up, even with an absolutely transparent or liquid filler. Such a procedure, which was the old-time method of finishing, is slow and expensive.

About 50 years ago paste fillers, some of them having a vegetable body, were in common use for finishing all porous woods. It had been discovered that it was better to fill the open cell cavities on the surface of woods having large tracheal vessels with a solid mass rather than with several coats of liquid surfacers. Various materials were tried—among them being cornstarch and wheat flour from the vegetable world, as well as other supposedly more permanent materials, such as whiting (calcium carbonate), China Clay, or Kaolin, which is a hydrated aluminum silicate, Silver White, which is a name given to several white silicate earths, plaster of Paris (sulphate of lime), and probably other similar substances were also used occasionally. All of these materials proved to be more or less unsatisfactory, because they were subject to decay or disintegration, or were not transparent enough, or expanded or contracted in the pores, or did not harden properly with the binders, or were too absorbent of shellac or varnish, or failed to meet expectations for some mechanical or chemical reason.

Silex, a comparatively new material to be used for the body of wood fillers, appeared in the Wheeler filler about 1876; but on account of its many superior qualities, it has nearly supplanted all other substances, especially in high-grade paste fillers.[5] Silex is one of the forms of silica, and is made by crushing to various degrees of fineness a dull-colored quartz rock called flint. Silica, which is very similar to silex, is obtained from ordinary quartz instead of flint.

---

[5] J. Gauld Bearn, *The Chemistry of Paints, Pigments, and Varnishes*, "Silex," p. 35.

The particles of silex which are made by crushing rock are in numerous rough shapes, such as wedges and needles, rather than in spherical forms. Such minute fragments will pack together with a proper binder and make a mass that will not easily break up or pulverize and come out of the cell cavities. Another good feature of silex is that when mixed with oils it becomes almost perfectly transparent; and, unless it is packed in considerable masses or is colored with pigments, it does not obscure the grain to an appreciable extent. The resultant clearness or transparency of the finish depends to some extent upon the fineness to which the silex is ground, because its oil absorption also varies with the size of the particles.[6] Silex, when unmixed with oil, is a white ground powder that is far from transparent.

128. Ingredients Used in Paste Fillers.—Many formulas have been used for making wood-fillers. Certain ingredients, however, are likely to be found in all of them that give good results, including:

1. A *body material,* or filler, often called a pigment, preferably silex, but which may be China clay, barytes, whiting, cornstarch, and the like. The purpose of the body material is to provide a hard mass that will plug the open ends of cells and fill in all cell cavities that form depressions below the general level of the surface to be finished. Silex is not usually considered to be a pigment.[7]

2. A *vehicle,* usually boiled linseed-oil (raw linseed-oil also gives good results), the functions of which are to act as a binder to the body material and to size the wood.

3. A *japan drier,* generally a light brown japan, which acts as a drier, and helps as a binder for the mixture.

---

[6] R. S. Morrell and A. de Waele, *Rubber, Resins, Paints, and Varnishes,* pp. 124, 125.

[7] Ibid., p. 124.

4. A *solvent* or thinner, preferably turpentine, but which may be naphtha or benzine. The solvent practically all evaporates, but it thins the mixture so that it can be applied to the surface with a brush.

5. *Coloring-matter,* which usually consists of colors ground in oil, is added, in order to stain the filler or both the wood and the filler. The so-called natural or white fillers contain no coloring-pigments.

Most of the paste fillers now sold on the market are probably made with silex as a pigment or body for the filling mass. These ready-mixed fillers are usually put up in compression-top cans, containing 1, 5, 10, or 25 pounds. Such containers will keep paste filler almost indefinitely, if the covers are driven tightly into place thereby sealing the can when the mixture is not being used. Prepared fillers always must be remixed by stirring thoroly, and usually require thinning with turpentine, naphtha, benzine, or even gasoline before being used. Such fillers can be purchased under the following names: ebony; red, brown, light, and dark mahogany; natural or transparent; antique, Antwerp, dark, and golden oak; walnut; and special white.

An experienced workman can make one gallon of thinned paste filler, which contains six to eight pounds of ready-mixed filler with thinner, cover as much as 300 square feet of surface. The area that can be covered with a given amount of paste filler varies greatly with the kind of wood and the experience of the man.

A practical formula for making "natural" or colored paste filler is as follows:

(a) 2 quarts boiled linseed-oil.
(b) 1 quart brown japan.
(c) ½ pint turpentine.
(d) Add silex gradually while mixing until a stiff mass is obtained.

Some formulas suggest ¼ to ⅙ by weight of China clay instead of all silex. A better blending of substances is secured by permitting the pasty dough to stand one or two days before thinning.

Thin the silex mixture with turpentine or benzine to the proper thickness for application with a stiff brush.

Color the filler with pigment colors ground in oil. If strong colors are required, it is often best to stain with oil-soluble coal-tar dyes rather than with pigment-colors. If the mass of pigment-color is equal to 1/6 to 1/4 of the amount of silex, the filler would be weakened in adhesion and would not be as firm a mass in the cells; consequently aniline or other coal-tar colors are preferable in such cases. Colored paste fillers which are to go over stained or dark wood are generally made slightly darker in tone than the surfaces which are to be filled. This is done because the wood slowly darkens with age and later on will be as dark as the filler which is used.

Home-made fillers containing brown japan in large quantities should generally be used within two weeks. If the mixture is too old, it becomes somewhat hard and does not work into the pores as well as it does when it is fresher and softer.

The solvents used in making paste fillers are very volatile; therefore, it is important that the mixture be kept in cans or buckets having closely fitted covers so that the containers are practically air-tight.

129. Colored Pigments Used in Producing Special Paste Fillers.—Painters' pigments ground in oil are generally used to give color to paste fillers. Dry colors, which are mineral pigments in the form of powders, are sometimes used, but they are more opaque and weak in chroma.

Manufacturers of fillers, however, furnish paste fillers colored to the standard tones or effects; and these can be obtained under such names as the following: natural or uncolored, antique oak, golden oak, dark oak, mahogany, walnut, and the like. Special fillers for various kinds of wood can easily be mixed and colored.[8] See Table IV.

---

[8] A. A. Kelly, *The Expert Wood-Finisher*, pp. 26, 27.

TABLE IV.

Coloring Natural Paste Filler with Pigments Ground in Oil

Name of Wood or Color Effect	*Colors to be Mixed with the Natural Paste Filler*
Ash (Light brown)	Natural filler is often used, or colored with burnt umber. Various oak fillers can be used.
Birch (Reddish)	Paste filler is seldom used; tone with yellow ochre, burnt sienna, and burnt umber.
Cherry (Reddish brown)	Filling is generally omitted; use 50 per cent each of burnt sienna and yellow ochre; or Venetian red or burnt sienna.
Chestnut (Dark brown)	For light effects, natural filler is used. Burnt umber. Oak fillers are often used.
Ebony (Black)	Drop black.
Gray (White over gray stain)	Tinges of light gray with touches of ultramarine, yellow ochre, and yellow; or zinc oxide ground in oil with paste filler.
Green, Forest (Dark green over yellow-green stain)	One part chrome green to 20 parts natural filler, or chrome green and drop black (equal parts) and often a little brown, such as burnt umber.
Gun Metal Black	Fill with fine black graphite, japan drier, and benzine.
Mahogany, Adam brown (Very dark)	Vandyke brown and a touch of rose pink.
Mahogany (Light brown)	Tint with Vandyke brown.
Mahogany, Red	Burnt sienna, rose pink, and drop black; or burnt sienna, Vandyke brown, and yellow ochre; or, for a browner tone, burnt umber, Vandyke brown, and rose pink; or 60 per cent burnt sienna and 40 per cent maroon lake.
Mahogany, Sheraton (Very dark brown)	Vandyke brown 5 parts, burnt umber 4 parts, and rose pink 3 parts with natural silex paste.
Oak, Antique (Very dark)	Vandyke brown and drop black in oil; or Vandyke brown 3 parts, and Venetian red 1 part, to 20 pounds of filler.
Oak, Antwerp (Black)	Drop black in oil to make black filler. Use over shellac wash.
Oak, Bog (Dark green stain)	Vandyke brown two parts, drop black in oil one part.
Oak, Baronial (Stain is a warm dark brown)	Filler not generally used. Vandyke brown. Wax finish over shellac, or use flat varnish.
Oak, Dark.	Eighty per cent of raw sienna, with 10 per cent each of burnt sienna and burnt umber.

TABLE IV.—Continued

COLORING NATURAL PASTE FILLER WITH PIGMENTS GROUND IN OIL

Name of Wood or Color Effect	*Colors to be Mixed with the Natural Paste Filler*
Oak, Dutch brown (Dark reddish-brown stain)	Match stain with Vandyke brown with touch of burnt sienna. Use over a shellac wash which sizes the stain.
Oak, Early English (Very dark yellowish or greenish-brown stain)	Drop black in oil and Vandyke brown, equal parts, or nearly all black.
Oak, Flemish or Flanders (Black stain, very dark green, and very dark brown stains are used)	Some finishers use no filler. Drop black in oil, if filled; or black with part burnt umber for black or green Flemish. For brown Flemish, color filler with Vandyke brown.
Oak, Fumed (Orange brown, or brownish-yellow in various rather light shades)	No filler is used in standard finishes. If filler is desired for special effects, use a dark filler, or match the stain with burnt sienna, yellow ochre, and touches of brown, or even green or blue to neutralize slightly.
Oak, Golden (Yellowish stain with a dark filler)	Asphaltum with Vandyke brown, burnt umber, drop black, and yellow ochre. Sometimes a filler is made with two parts Venetian red and one part burnt umber.
Oak, Jacobean (Dark orange brown)	No filler is used. High lights wiped in stain.
Oak, Light (Natural color)	Use a little yellow ochre, or yellow ochre and raw sienna in the proportion of 50 per cent each.
Oak, Malachite (Very dark blue-green stain)	Drop black 5 or 6 parts to one each Vandyke brown and chrome green. Filler must be very dark green or all black.
Oak, Mission (Shades vary from gray to brown)	Pores often unfilled, especially with brown tones. Fillers of gray, green, and brown may be used. Fillers of zinc white and floor-wax can be used over a gray stain and a shellac wash. Brown filler is made of three parts burnt umber and one part Venetian red. Fillers should match color of stain.
Oak, Olive (Stain is dark olive green)	Filler is colored with drop black and applied over olive-green stain.
Oak, Novelty colors (Water-stains used first)	Use a white filler of zinc white with natural filler, or tint silex filler with green, gray, or brown, and use over a dark stain making pores show up lighter.

TABLE IV.—Continued

COLORING NATURAL PASTE FILLER WITH PIGMENTS GROUND IN OIL

Name of Wood or Color Effect	*Colors to be Mixed with the Natural Paste Filler*
Oak, Silver and Kaiser (Stain is silver gray but has a tinge of yellow)	Fill over stain with zinc white and linseed-oil, thinning oil with five to seven parts naphtha or turpentine; or use Wheeler's Special White Filler for white-pored effects. Silver-gray paste filler or natural filler may also be used.
Oak, Weathered	No filler is used for the standard effect. A filler of warm or neutral gray to match the stain color could be used if a flat varnish instead of shellac and wax finish is desired. Sometimes a black filler of drop black ground in oil with natural filler is used.
Redwood	Not usually filled. Burnt sienna and a touch of rose pink; or burnt umber, Vandyke brown, and burnt sienna.
Rosewood	Use a shellac wash under the filler. Tint filler to match color of wood with 3 parts Vandyke brown (preferably ground in japan) to 1 part rose pink in japan or oil.
Walnut, American (Black walnut in natural color)	Fifty per cent Vandyke brown and 50 per cent burnt umber in oil to match walnut wood in color; or use burnt umber and a small amount of rose pink or Venetian red. For an evener tone, stain before filling with an acid water-stain, a Dakalite walnut stain, an oil-soluble dye, or a drying mixture of boiled linseed-oil, turpentine, and japan drier tinged with Vandyke brown in oil.
Walnut, Antique (Pores to be white or with a gray tinge)	Use a white paint filler with 3 parts white lead in oil one part zinc oxide in oil, thinned with a drying-solvent of 2 parts japan drier and 1 part each of turpentine and benzine. Wheeler's Special White filler may be substituted for the paint filler. Filler may be grayed slightly.
Walnut, Circassian (Transparent effect)	Apply a drying-oil composed of 1 to 2 parts boiled linseed-oil, 1 to 2 parts turpentine, and 1 part japan drier. Fix the color with a shellac wash. Color filler with Vandyke brown, or burnt umber and reds to match wood, but of a slightly darker tint.

130. Brushes and "Picking-Sticks" for Filler.—Three kinds of brushes are useful to the workman in applying filler: (1) a 3″ or 4″ coach duster having rather fine stiff bristles makes an excellent brush for dusting and removing sand particles and broken wood fragments from wood surfaces that are to be filled. A house-painter's duster having rather fine stiff bristles may be used. (2) Special brushes for applying filler can be obtained of brush manufacturers. Filler brushes should be quite stiff, so that the bristles will be sure to enter the lowest parts of the exposed cell cavities of the wood, Fig. 11. Brushes should be of good size and have plenty of bristles in order to hold considerable filler. An old half-worn or short-bristled flat paint-brush may be used for large work. Oval or round brushes are preferable for small work, because they hold more filler where narrow brushes are needed. (3) Picking brushes are often needed for rubbing out the excess filler from uneven surfaces, such as carvings and moldings. Special very stiff and rather coarse-bristled brushes, with the handle on the back like a shoe-blacking brush, are made for this purpose, and can be bought on the market under the name of picking brushes. They should not be used where the filler can be rubbed off in the usual manner.

Picking-sticks, about ¼″ to ⅜″ in diameter, and 6″ or 8″ long, may be made of maple dowel-rods, or from close-grained hickory or some other similar wood. Frequently they are whittled and sanded with one wedge-shaped end for scraping the filler out of corners and other places where it can not be rubbed off. The other end generally tapers to a rather sharp point. Chisel-like scrapers of various sizes and shapes can be made at the ends of these picking-sticks. Bone, horn, and old tooth-brush handles are favored by some finishers as material for home-made picking-sticks. A narrow strip of cotton cloth is frequently held tightly over the wedge-shaped end of the picking-stick when removing the filler. If the filler becomes too hard, it may be necessary to dampen the cloth with turpentine when scrap-

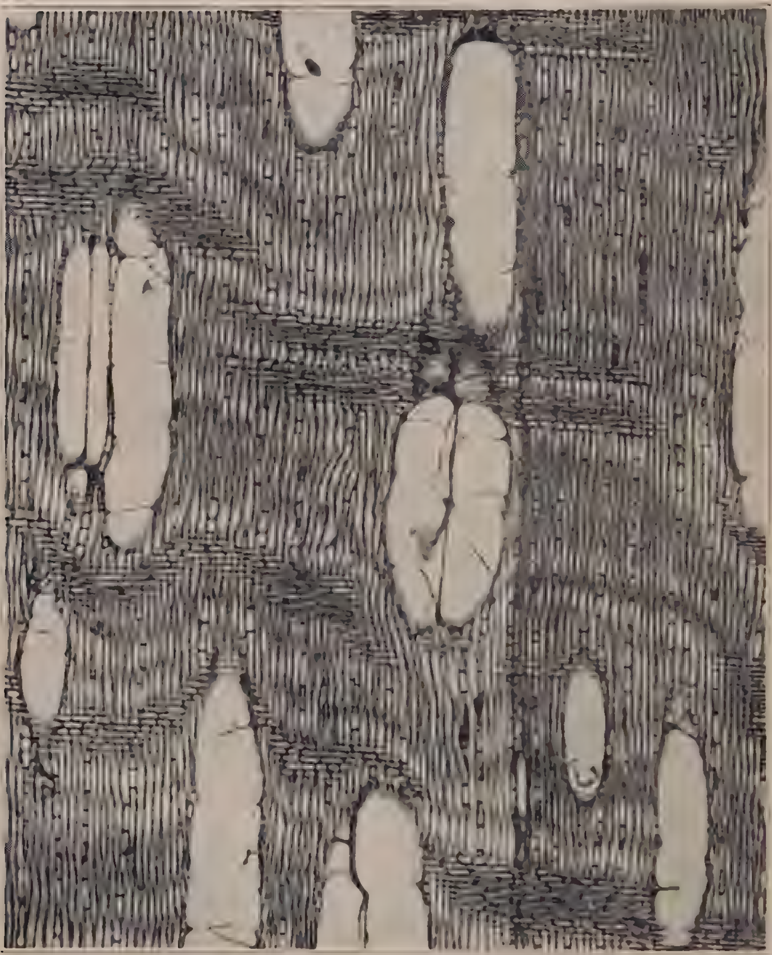


FIG. 11—OPEN PORES SHOW THE NEED OF DUSTING BEFORE FILLING

This radial section of black walnut shows the open pores and the need of dusting with a stiff brush to clean out the fragments of woody tissue before applying wood filler. Magnification 50 diameters. Courtesy of the Forest Products Laboratory, Madison, Wisconsin.

ing out the corners where the mixture has dried too long.

131. Brushing and Dusting Wood Before Filling.—Experienced wood-finishers make a practise of brushing wood surfaces with a stiff brush lengthwise of the grain just before filling. Such a brushing, if done thoroly, removes many loosened or broken fragments of cell walls that otherwise might come off after filling and leave specks or small defects. The cell cavities on the surface are also cleaned out of small fragments of sand and dust neither of which mixes well with a filler. The wood-finisher generally says that brushing and dusting open up the pores of the wood and prepare the surface to receive a filler. See Fig. 12.

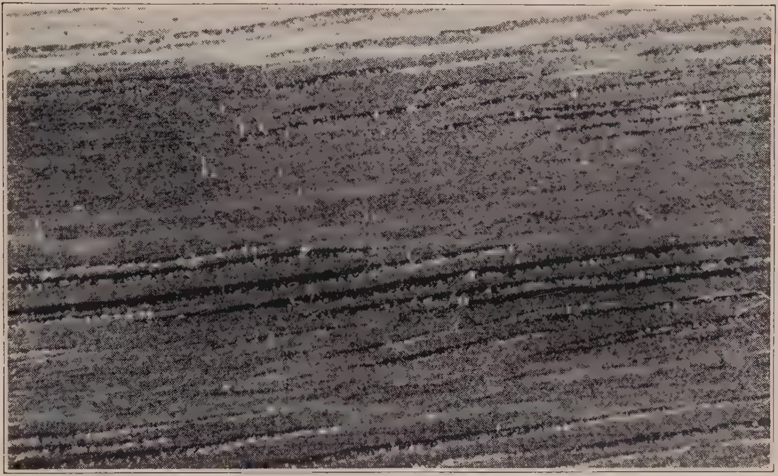


Fig. 12—Unfilled Pores of Oak Wood

This photograph shows the pores or tracheal vessels of oak wood without any filler. Fuzz also shows plainly on the surface. Magnification about 5 diameters.

132. Sanding Water-Stained Surfaces Before Filling.—A cleaner, less muddy effect can be secured over water-stained surfaces if they are given a wash coat of shellac and sanded after the shellac is thoroly dry. Use dry sandpaper, 3/0 or 4/0, held in the hand or over a felt pad, as water is not good for rubbing shellacked surfaces. The sanding must be done very carefully, or streaks and corners will be sanded too much, and the even tone of the stain will be spoiled. The wash coat of shellac should consist of seven to ten parts of alcohol to one part of liquid shellac. If the shellac has four pounds of gum to the gallon of denatured alcohol, a wash-coat should consist of eight parts of denatured alcohol to one part of liquid shellac. The shellac wash stiffens any fibers that were raised above the general level of the surface by the staining process, and a light sanding removes all these fragments flush with the surface. Wood-filler can be rubbed crosswise from such a surface leaving it clean and clear in appearance.

133. Process of Filling.—Filling wood with paste filler is not a difficult operation, but it requires knowledge of materials, and proper equipment, in addition to skill that comes from experience and good methods of work. Preliminary processes of finishing may precede the application of filler. Sometimes the wood is stained and allowed to dry, and the filler is applied over the stain. The filler may "lift" or raise the stain when this method is used. In order to prevent this change of shade, a wash consisting of a very thin coat of shellac is frequently put over the stain to hold it in place and prevent the "lifting" of the color.

If shellac of the standard or ordinary mixture is used, instead of a wash as suggested, the pores of the wood will be coated and filled with such a thick smooth covering that the wood-filler will not stay in the pores on account of poor anchorage for the filler pigment or body material. Paste filler can be applied successfully over a wash coat of shellac without raising the stain or changing the shade or tone of the color.

Sometimes an oil-stain is applied and not rubbed; and, after about 20 minutes, a filler is brushed crosswise over the wood, absorbing some of the excess stain. At other times filler that is either stained or "natural" is applied to unstained and unshellacked wood surfaces as a first coat of finish. If a stained filler is used, the wood may be stained and filled in one operation. The stain in this case does not usually penetrate deeply into the wood, and the general tone is light because less color is absorbed by the wood from the filler than is usual with most other methods of staining. Greater penetration of the stain can be secured, however, by substituting about 15 or 20 per cent of benzol for that much benzine in the solvent or thinner.

Paste filler must be thinned to the proper consistency with turpentine, benzine, or naphtha before use. Should it be too thin it will not fill the pores of a coarse-grained wood which has large open cells, because it would contain too little pigment. On the other hand, if the filler is too thick, it will not enter the cell openings properly, especially when applied to woods composed largely of tracheids, or having tracheal vessels that are relatively small in size.[9]

Ordinarily, paste filler should be about as thick as paint when it is applied. The finisher should remember, however, to use a thick filler on woods with large open pores and a rather thin filler on woods with small pores. Woods with very small pores, such as are found in the conifers, do not need a paste filler and are usually given a coat of transparent or liquid filler.

Linseed-oil, preferably boiled, is sometimes painted over wood just before paste filler is applied, to prevent too great absorption of oil from the filler by the wood, thus reducing the binding qualities of the vehicle in the pores. If the filler has a proper amount of oil mixed with it, the preliminary oiling is unnecessary. Oiling always darkens wood and is pleasing in some cases, as with black walnut; it usually is displeasing with very light woods, such as pine and maple, and even with oak. Paste fillers that are to be used over surfaces that have had a shellac wash do not require as much oil in their composition as is desirable in those that are to be spread on unsized wood.

Paste filler should be painted on the wood with a large, short-bristled, stiff brush, which should be kept moderately wet or full of the liquid. The mixture in the can should be stirred often to keep the silex or body material from settling. The important thing in the application of filler is to force the pastelike mass down into the pores, and drive air bubbles out, thereby preventing specks or pinholes. This can be accomplished by working the filler into the pores by spreading it lengthwise of the grain, and by going over it crosswise with a rather wet brush.

---

[9] A. C. Newell, *Wood and Lumber*, "Tracheal Vessels and Tracheids," pp. 34-36.

Some finishers apply filler lengthwise of the grain only, while others say it should be brushed on crosswise. The important things are: to be sure (1) that the pasty mixture goes into the pores as deeply as possible; and (2) that the cell cavities are completely filled. Paste filler does not set quickly, consequently there is no danger of spoiling a finish by working the surface over and over with a brush.

Dulling or setting of paste filler for furniture usually requires about 20 minutes with most of the good ready-mixed commercial silex fillers of the present day. An excess of oil, the use of raw instead of boiled oil, and lack of proper driers—all cause the filler to set slowly. The quick-drying thinners cause it to set more rapidly. If the filler dries too rapidly, add a little more linseed-oil; but one should remember that too much oil makes a sticky mass that may pull out of the pores because it is tough and not in a condition to wipe off properly, and also that an excess of oil in the filler may injure the varnish coats over it. A finisher should add japan drier up to about ½ pint to the gallon of filler, if there is too little binder and the mixture pulls out of the pores in rubbing. On the other hand, a filler which is too stiff, lacking in benzine or turpentine, will not brush into the pores properly, and is very apt to pull out of the cell cavities during the wiping process.

Two very important rules should be remembered, namely: *first*, paste fillers contain ingredients that readily settle to the bottom of the can or pail, and, therefore, it is very important that the mixture should be stirred thoroly very often, at least once in every three to five minutes; *sec-*

ond, the finisher must rub the filler at just the right time, because if it is rubbed too soon the filling mass will pull out of the pores, and if the finisher waits too long the excess of material above the surface that ought to be removed has dried too hard, and will not come off unless it is softened with turpentine or benzine.

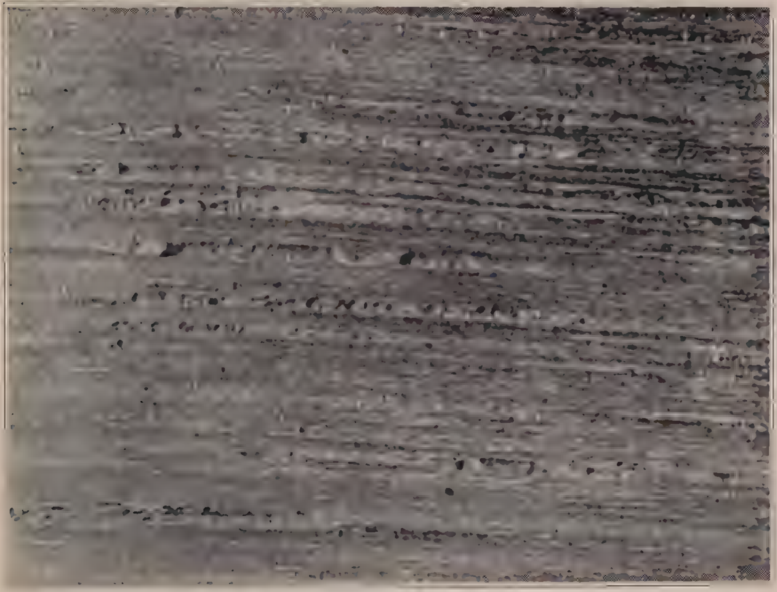


FIG. 13—CHESTNUT WOOD POORLY FILLED

The filler has come out of some of the tracheal vessels or pores. This is a common fault when filling is done by inexperienced persons. Refilling is the remedy. Magnification about 5 diameters.

134. Rubbing Paste Filler.—Rubbing off the filler in such a manner as to leave well filled pores and a level surface is the real test of a wood-finisher's skill. After painting on the filler the condition of the surface must be watched, and the excess of the dulled mixture should be rubbed off crosswise of the grain at the proper time. If the filler is rubbed too soon, before the thinner has evaporated, the thickening body mixture of silex and pigment will pull out of the pores because it has not had time to stiffen and form firm anchorages, and a poorly filled uneven surface will be the result, Fig. 13. If the finisher waits too long, the filler will not come off the surface easily; and some of it may pull out of the pores, as it is too stiff, instead of being cut off just at the surface. The filler that has settled down into the ruptured cell cavities should not be disturbed, while all excess which is above the surface of the wood must be rubbed or scraped off. Filler should be rubbed soon after it has dulled and no longer looks wet, for prompt action at that time is necessary to secure good results. The finisher should not fill too large an area before he begins the rubbing process.

Various materials can be used for rubbing off the filler from wood surfaces. The newly filled floors of buildings are frequently rubbed with soft shavings, saw dust, or excelsior, because these substances cost little or nothing and are available. Shops and furniture factories generally use better material, such as hairlike sea-moss or sea-grass which is commonly used in upholstering, jute or flax, or hemp tow, rags, burlap, or even cotton-waste which is objectionable if it leaves lint on the surface. Almost anything will answer the purpose which is not too stiff and is somewhat absorbent, that will scrape or rub off the excess filler from the surface without digging it out of the pores.

Crosswise rubbing of paste filler is the proper method, since rubbing lengthwise of the grain tears the filler out of the pores to a greater extent. The finisher should obtain a handful or pad of jute tow, sea-grass, or rags, and rub one surface after another crosswise with considerable pressure, taking more material as soon as that in the hand becomes too wet or full of filler. A cleaner surface can be obtained by making a few light strokes with cotton cloth or rags lengthwise of the grain in finishing the process, thus removing the cross-lines of filler left by the first hard rubbing.

Two or more coats of filler are sometimes required to fill the pores completely. If the first coat is too thin, a sec-

FIG. 14—BLACK WALNUT HIGHLY MAGNIFIED SHOWING WOOD-FILLER IN THE PORES.

The dark streaks are made by a very dark walnut paste wood-filler in the tracheal vessels or pores. The filler has largely come out of the tracheal vessel running lengthwise of the picture and a little to one side of the middle. This condition is indicated by brilliant spots of light.

ond application is added. Since upright or slanting surfaces do not hold the filler in the pores as well as horizontal surfaces, the mixture which is to be used on vertical surfaces should be quite thick, or it may run out of the pores. Examination will show whether the pores are full of the filling material.

A second coat can best be applied as soon as the first one has become set or dull. After a filler has been rubbed, it is wise for an inexperienced workman to examine portions of various surfaces of a filled article using a pocket magnifier of from 12 to 18 enlargements. A hand-glass of even lower magnification will help. If the filling is not well done, the glass will show it instantly, Fig. 14. Additional coats of filler can be applied, if the pores are not full, after rubbing off the excess from the first application. It is thought best by many finishers to paint another coat of rather thin filler over the rubbed surface as soon as possible, at least before the mass in the pores is thoroly dry and hard. This second coat of filler can be rubbed when it has set just as was the previous application; and, usually, a satisfactory level surface properly filled is the result. Sometimes a second or third coat is given to a filled surface that has dried hard, and the result is generally satisfactory.

135. Drying Paste Filler.—The rapidity of drying of paste filler depends upon atmospheric conditions, such as warmth and dryness, and also upon the amount and the kind of oil used, the quantity of driers, and the volatility of the solvents. Raw linseed-oil in the mixture and damp cool air check or slow up the drying of filler in wood. Under ordinary shop conditions most of the standard paste fillers sold on the market should have at least 48 hours to dry before shellac or any other finish is applied over them. Sanding can generally be done after 24 hours. Oxidation of linseed-oil, especially raw oil, is a slow process; and, as there is linseed-oil in paste fillers, plenty of time must be allowed for the drying of the filler or various finishing troubles may follow later on after the article is varnished.

136. Sandpapering a Filled Surface.—Filling always leaves a slightly rough surface, which should be sanded very lightly with No. 00 or No. 000 sandpaper. Small fragments of filler may be left on the surface after rubbing; the filled surfaces in the cell cavities may be slightly rough or not quite level, this condition being revealed by a magnifier; and in addition to these, the fuzz on the surface of the wood may have been very slightly raised by the oil in the filler or the solvents that were used to make it spread to better advantage, Fig. 15. Fine sandpaper should be used, and it should be handled with great care to prevent cutting thru at corners and other exposed places.

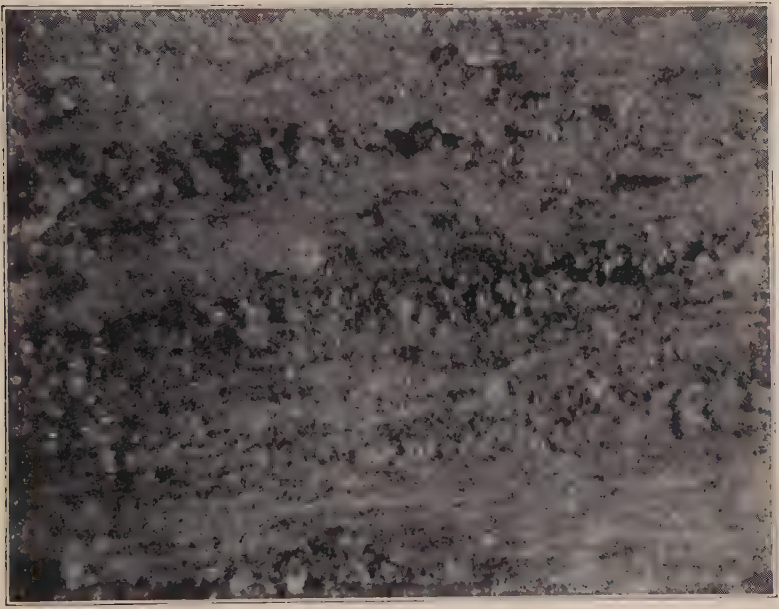


Fig. 15—Filled Surface of Walnut Wood as Seen Thru a High-power Microscope

Some of the filler has been pulled out of the pores. The entire surface shows great roughness, caused by improper cleaning of the filler and fuzz. The remedy for such a condition is sandpapering.

The inexperienced finisher should be warned to sand lengthwise of the grain with light strokes, or his work may be damaged. The sandpaper should not be placed over a hard block and used in that manner, for streaks and spots may be cut thru the filler and perhaps a stain coat that was applied previously. Soft felt blocks should be used, or the paper may be held over the hand for much of the sanding.

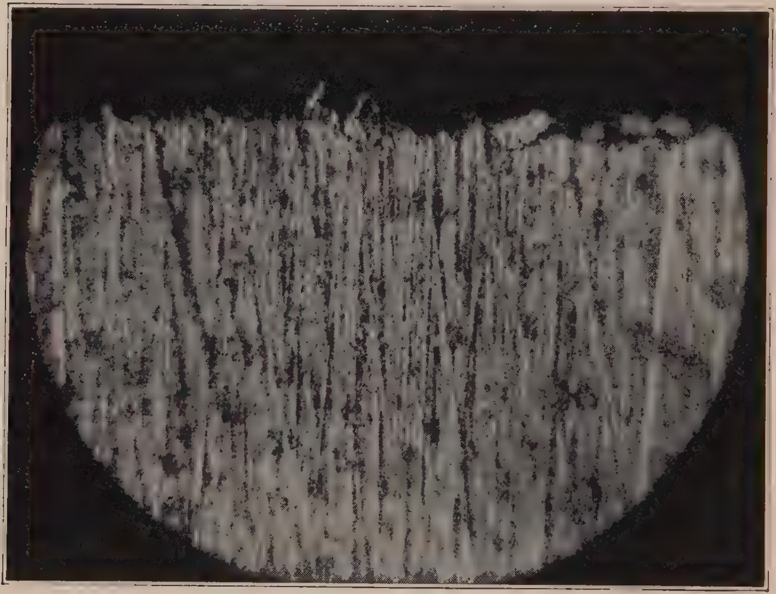


FIG. 16—SANDPAPER SCRATCHES ON THE END GRAIN OF WALNUT THAT HAS BEEN FILLED AND SHELLACKED

Very highly magnified.

The surface has been very badly scratched with No. 2/0 sandpaper. Remedy—use finer sandpaper.

The rough surface at the top of the picture is usual on a smoothly-planed but unsanded surface. Remedy—sandpaper all surfaces and round off all arrises.

Double-coated split sandpaper is thin and flexible, and convenient for some kinds of sanding.[10] Fine "Wetordry" waterproof garnet finishing-paper, over a "wetordry" felt pad well moistened with water, can also be used to advantage over filled surfaces. See Fig. 16.

The appearance is often improved by wiping a filled surface with a cloth moistened with benzine as a final operation after the sanding has been completed. Small particles of sand and fragments of wood together with any muddiness from excess portions of filler, are removed leaving an effect of greater transparency as a result of the wiping operation.

---

[10] See Section 9, "Use of Sandpaper," p. 30.

TABLE V.

Kinds of Filler Used on Varieties of Wood

Pores invisible to the eye. Paste filler not needed. Use liquid filler or shellac.	Pores small but generally visible. Paste filler sometimes used. Liquid filler or shellac generally used.	Pores large. Paste filler usually used. Liquid filler unsatisfactory.
Basswood	Basswood (sometimes)	Ash
	Beech	Beech
	Birch	
	Boxwood	
Cedar, red and white	Cherry	Butternut
Cucumber		
Cypress	Cypress (after water-stain)	Chestnut
		Cocobola
Ebony	Cottonwood	Coffee-Tree Wood
Fir (including Douglas)		Elm
	Gumwood	Hackberry
Hemlock		Hickory
Holly		Locust
Larch or Tamarack		Mahogany
Magnolia		
	Maple, hard and soft	Mahogany, Philippine
		Oak
		Osage Orange
		Rosewood
Pine, white and yellow	Sycamore	Sassafras
Poplar or Whitewood		Satinwood
		Sycamore
Spruce		Vermillion
Tupelo	Redwood	Walnut, black
Willow		Walnut, Circassian

137. Certain Woods Require a Paste Filler.—A complete enumeration of all woods that require paste filler would be hard to prepare, but a list of typical species may be of assistance. As a general rule, woods that have open pores or cell cavities that are plainly visible to the naked eye should be filled with a paste filler. A wood that has been colored with an oil-stain containing linseed-oil does not need a paste filler as much as one stained with a water-stain. For this reason woods having fine cell openings, such as birch, are frequently filled after a water-stain; and, generally, they are not filled after application of linseed-oil stain, because the drying-oil mixed with the color sizes the wood and plugs the cell openings to some extent. The volatile oil-stains made from a solvent and an oil-soluble coal-tar dye do not size wood much more than does water-stain.

The list of woods in Table V, based largely on the size of the cell cavities, is suggestive in deciding whether a given kind of wood should be filled with a paste filler, but it must be remembered that special types of finishes for unusual effects may be the determining factor.

In some cases Table V shows the name of a wood in two columns. This indicates that at least two methods of finishing these woods are commonly used, and that both methods are considered to be good under certain conditions.

138. Paste Fillers Are Best on Floors.—The finishing of floors is not considered in Table V, for the reason that liquid fillers are not satisfactory on any kind of wood used for floors.[11] More suitable finishes for floors can be obtained by treating all kinds of flooring, both hardwoods and softwoods, with a paste filler in order to give a good foundation of very hard, non-absorptive, long-wearing material as an undercoat for varnish. All woods are porous, because cavities or openings exist in all kinds of cells in the various woods.[12] The microscope shows the closest-grained non-porous woods to be full of cells, and the end-grain of such a wood, under a glass, appears like a sieve. The finest particles of a properly-ground silex are small enough to lodge to some extent in the cells of even the closest-grained wood and plug up or fill the cell openings.

---

[11] E. I. du Pont de Nemours and Company, *Modern Wood-Finishing*, "Floor-Finishing," p. 51.

[12] A. C. Newell, *Wood and Lumber*, Chapter III, "Wood-Cells," pp. 28-48.

REFERENCES—CHAPTER X

Wood Fillers

J. G. Bearn, *The Chemistry of Paint, Pigments, and Varnishes,* "Silica," p. 35.

E. I. du Pont de Nemours and Company, *Modern Wood-Finishing,* especially pp. 16, 51.

Grand Rapids Wood Finishing Company, *Better Wood-Finishing,* Chapter V.

H. R. Jeffrey, *Wood-Finishing,* Chapter III, pp. 40-53.

A. A. Kelly, *The Expert Wood-Finisher,* "Wood Filling," pp. 16 to 61; "Fillers for Various Woods," pp. 26-7.

F. Maire, *Modern Wood-Finisher,* Chapters II, IV, VIII, XVI.

R. A. McGee and A. G. Brown, *Instruction Units in Wood-Finishing,* pp. 16-21.

R. S. Morrell and A. de Waele, *Rubber Resins, Paints, and Varnishes,* "Silica," pp. 124-5.

A. C. Newell, *Wood and Lumber,* "Trachael Vessels and Tracheids," pp. 28-36, 49, 53.

W. K. Schmidt, Furniture Manufacturer Magazine, March, 1923, p. 111; and April, 1923, p. 175.

W. K. Schmidt, *Problems of the Finishing-Room,* Chapters 18, 19, 82.

F. N. Vanderwalker, *Wood-Finishing, Plain and Decorative,* Chapter XII, pp. 136-152.

CHAPTER XI

SPIRIT-VARNISHES

139. Spirit-Varnishes Defined.—Shellac, dammar, mastic, and sandarac varnishes are quick-drying well-known finishes which are often called spirit-varnishes. The term spirit-varnish seems to have a slightly different meaning in England and France from that which is common in the United States. Abroad, the term spirit-varnish refers to a mixture made from one or more gums or resins that may be dissolved in alcohol, turpentine, acetone, or similar volatile solvents, but which contains no drying-oils, such as linseed oil or tung-oil. In some foreign countries, it seems customary to classify alcoholic spirit-varnishes and turpentine spirit-varnishes in one group.[1] In the United States, two groups are sometimes made, gums or resins dissolved in alcohol being called spirit-varnishes, while those cut with turpentine are called volatile-oil varnishes.[2] Other American authorities use the foreign classification.[3] In this book, the two groups are classed together, and the term spirit-varnish refers to solutions of gums or resins and volatile liquids. Some resins such as dammar, mastic, and elemi are largely soluble in both alcohol and turpentine.

140. Resins Used in Spirit-Varnishes.—Various resins, frequently in mixtures, are used in spirit-varnishes. The solvents which are most commonly selected are turpentine or alcohol, altho many of the resins will dissolve, either wholly or in part, in benzol or ether. It should be remembered, however, that some resins are largely or entirely soluble in turpentine and only partly soluble in alcohol. In other cases the reverse is true. The following lists indicate the solvents that can be used with several of the resins:

---

[1] See J. G. Bearn, *Chemistry of Paints, Pigments, and Varnishes*, Chapter XIX, p. 232; and Ch. Coffignier, *Colors and Varnishes*, Chapter XIII, p. 214.

[2] See Berry Brothers, *Varnishes and Varnishing*, p. 3.

[3] See G. B. Heckel, *A Varnish Cathechism*, p. 6.

Soluble in turpentine or benzol

Dammar
Mastic
Rosin
Elemi

Soluble or nearly soluble in alcohol

Sandarac
Shellac
Rosin
Elemi
Manila gum, soft
Benzoin

Partly soluble in turpentine or benzol

Sandarac (26% to 33%)
Manila gum, hard (27% to 36%)
Manila gum, soft (36% to 42%)

Partly soluble in alcohol

Dammar (71%)
Mastic (64%)
Brazilian copal (62%)
Manila gum, hard (44%)

THREE USEFUL SOFT GUM VARNISHES

141. Dammar-Varnish.—The best known of the clear or transparent varnishes commonly sold on the American market is called dammar-varnish. This resin, classed as a soft resin, comes from the East Indies, is harder than rosin, but is much softer than are the copals in general. Dammar resin is frequently dissolved in turpentine in which substance it is almost completely soluble; while, if alcohol is the solvent, there is about 29 per cent of residue remaining which is insoluble.[4] Other solvents which are sometimes used in dammar-varnishes are carbon tetrachloride, benzine, heavy naphtha 48°, and heavy benzol.

Dammar-varnish when spread upon a surface does not show the brilliancy of a shellac finish, nor does it have the durability of good fixed-oil varnishes which include linseed-oil or some other drying-oil in their composition. In such finishes, the turpentine, alcohol, or other volatile solvent dries out leaving a thin film consisting of the gum or gums spread over the surface.

Like other spirit-varnishes, dammar-varnish dries rapidly, because the solvents used evaporate quickly leaving a rather glossy and moderately hard film. Dammar-varnish is used on light or white surfaces at times in place of a fixed-oil varnish, which would usually slightly darken the tone on account of the presence of drying-oils. The film or coat left by applying dammar-varnish is not very durable because the resin becomes weak in cohesion and gradually rubs off. This varnish should be applied quickly—much as shellac is flowed over a surface—because it dries quite rapidly after being spread with a brush.

---

[4] See R. S. Morrell and A. de Waele, *Rubber, Resins, Paints, and Varnishes;* Table on p. 87.

Dammar-varnish, with its greater transparency as compared with oil-varnishes or even shellac, is used occasionally when it is desired to preserve the natural color of wood or other materials. A few years ago, when burnt-wood designs or decorations in pyrography were popular, dammar-varnish was often used for finishing boxes, plates, waste-baskets, and other small articles of basswood or holly in order to keep the unburned portions of the designs as light in tone as possible. Dammar-varnish has been used rather largely by paint manufacturers to impart a gloss to paints, and is sometimes mixed with zinc white in the preparation of white enamels because it contains no linseed-oil which is apt to turn yellow with long exposure to light.

Dammar-resin is produced by various living pinaceous trees of the genus *Dammara,* which grow in the East Indies chiefly, and to a minor extent in Australia and New Zealand. The best dammar-resin comes in five grades from the Dutch island of Java, and is known as *Batavia* from the name of the colony's capital city. Other dammar-resins sold on the market are shipped from Padang, Sumatra; Borneo, and Singapore.

Dammar-varnish is made up in varying proportions of resin and solvent, the following being suggestive:

Dammar-gum, Batavia Grade A, government standard, or Singapore dammar-gum, 4½ to 5 parts.
Turpentine, 6 parts.

Transparent Picture-Varnish:

Dammar (pale gum), 12½ parts.
Camphor gum, 1 part.
Turpentine, 25 parts.

A tougher more elastic dammar varnish:

Dammar (Singapore, or Grade A, Batavia), 2 parts (by weight).
Sandarac, 1 part.
Mastic, ⅕ part.
Turpentine, 4 parts.

The following is a United States Navy Department (52V2a, 1914) specification for dammar-varnish:[5]

> Composition I.—To consist exclusively of a solution of pure dammar-resin in petroleum spirits (turpentine substitute) and to be absolutely free from all foreign matter. To contain not less than 55 per cent nor more than 60 per cent by volume of petroleum spirits.

142. Mastic-Varnish.—The most important European resin, with the exception of colophony (col′o-pho-ny) or colophonium, which are other names for common rosin, is *mastic,* which comes largely from Chios, one of the Greek islands located in the Aegean sea. Similar resins are found in some parts of Greece, Africa, and Syria. Mastic-resin is the product of exudation from the lentix tree (*Pistacia lentiscus*), also called the Pistacia, a Mediterranean evergreen tree. The resin is thrown out in response to wounds, which are vertical incisions in the bark, and is collected in the form of spherical or slightly flattened tears or grains. After being exuded from a wound the liquid resin gradually becomes dry and hard. In Turkey it is sometimes used as a chewing-gum, tho it has a slightly bitter taste. Its odor is, however, rather agreeable and pleasing.

Mastic-gum soon softens when placed in the mouth and crushed between the teeth; while sandarac, a somewhat similar resin, is crushed into powder. A lentix tree in good condition is said to yield as much as eight to ten pounds of mastic-resin per year, if properly cared for during the gum-producing season. The tree, which is sometimes called the lentiscus, is hardly more than a shrub, usually growing to the height of only ten or twelve feet.

Mastic-resin, when it appears on the market, is of a pale yellowish or slightly greenish color. It is a very soft resin, fusing at a temperature slightly below the boiling point of water (95° C.). The gum, however, begins to soften at a temperature of about 85° C.

---

[5] See United States Department of Commerce, Bureau of Standards, Circular No. 69, *Paint and Varnish,* p. 27.

The active ingredient in mastic-resin is known as mastic-acid ($C_{40}H_{64}O_4$).

Mastic-resin is used to a limited extent in the manufacture of a number of transparent or colorless varnishes, being completely soluble in turpentine, ether, and benzol, and largely soluble in acetone. In alcohol, about 36 per cent of insoluble matter is left as a residue. Petrol ether has only a slight solvent action on the gum.

Artists are probably the chief users of various kinds of mastic-varnish. It is often mixed in small quantities with turpentine and boiled linseed-oil and used as a vehicle in mixing with artists' oil-paints, thus giving more luster to paintings than would be produced by using either linseed-oil or turpentine or a mixture of both.

One form of mastic-varnish, known as "*megilp*," contains boiled linseed-oil in its composition and is rather thick or gelatinous. "Megilp" is used by artists in connection with oil-paintings.

A portion of mastic-resin is sometimes mixed with dammar and other gums in order to make the resultant varnish more elastic and tough.

143. Sandarac.—Another resin that is completely soluble in alcohol is sandarac, which comes from a tree that is somewhat similar to the cypress or juniper and which is indigenous to North Africa, especially Algeria and Morocco. The Moors, who are the principal inhabitants of these countries, collect the sandarac-resin which is exuded to some extent naturally from the trees. Incisions are made in the bark, from which the tree throws out sandarac-resin, much as the longleaf and loblolly pines of the southern part of the United States exude crude turpentine-gum, the raw material from which turpentine and rosin are manufactured.

Sandarac is a rather hard member of the group of soft resins, and has a specific gravity of 1.073, which is high for a resin. On account of its hardness, toughness, elasticity, and great luster, it is sometimes mixed with shellac-gum in the production of alcohol-soluble varnishes. It was at one time often chosen as an ingredient of compounds, called lacquers, used to cover brass and other metals to prevent tarnishing. Sandarac-resin is also selected as an ingredient of various alcoholic spirit-varnishes, known as bookbinders' varnishes, label-varnishes, and photographic-negative varnishes.

The best quality of sandarac-resin comes to the market in the form of small, rather elongated, bitter tears or globules, which are of a pale yellowish color and have a slightly bitter taste, and a faint odor. The resin will not soften in the mouth in an attempt at chewing and can, by that means, be distinguished from mastic-gum.

Sandarac-resin fuses at a temperature of about 145° C. Other solvents for sandarac besides alcohol are ether and acetone. It is also partly soluble in chloroform (44 per cent), turpentine (26.4 per cent), and benzine (32.6 per cent).

SHELLAC-VARNISH—PREPARATION, APPLICATION

144. Lac-Gum.—Shellac, the best known and by far the most important of all the spirit-varnishes, is made from a rather hard resin called *lac,* which is shipped thruout the world principally from Calcutta, India. The resin itself is heavy for a material of this kind, and has a specific gravity varying from 1.113 to 1.214. The lac-gum or shellac of commerce is almost completely soluble in either wood or grain alcohol, leaving 3.6 per cent of residue which is known as shellac-wax.[6] Shellac-gum is, however, almost insoluble in dilute mineral acids, ether, linseed-oil, and turpentine (90.9 per cent), altho this last solvent, especially Venice turpentine is sometimes added to liquid shellac for special reasons.[7] It is interesting to know that shellac-gum is soluble in ammonia and alkaline solutions. The alkalies generally used for a mixture of this kind, which is known as a water-shellac, are borax and alkaline carbonates.[8]

---

[6] See Ch. Coffignier, *Colors and Varnishes,* p. 141.

The market quotations show various grades of shellac-gum, the best and highest-priced being known as D.C., V.S.O., and Diamond I. Other cheaper grades are superfine orange, fine, T.N. ("Truly Native"), garnet lac, button lac, and bleached (ground); the poorer grades being given last.

Shellac-gum, a resin commonly called *lac* or *"lakh"* (meaning 100,000), is produced by certain scale insects on various species of trees which are found especially in northern India, and Assam which was formerly part of eastern Bengal. Lac-resin at present is produced in Bengal, Siam, China, Ceylon, Burma, and the Malayan Archipelago; but Calcutta, India, remains the great market-place and shipping-port for this important industry.

The insect which excretes the lac is commonly called the *Coccus lacca,* but is also known as *Tachardia lacca,* and *Carteria lacca.* The insects incrust most commonly the twigs of various fig-trees which are sometimes spoken of as the Ficus. In various places they are found on 88 species and varieties of trees, including the mimosa, the acacia, the dalbergia tree which produces the rosewood of commerce, and also on India rubber and banyan trees. The deep red insects, about 1/12″ long while young, attach themselves to live twigs where they can puncture the bark with their beaks and suck up the sap from the growing stems. Important changes take place in each insect which exudes, thru the pores of its body a resinous material which finally incrusts it.[9] The exudations from innumerable insects ultimately cover the twigs with a thick layer, much as ice forms on branches of trees in winter in this country. The female insects, which are far more numerous than the males, form most of the incrustation of gum about themselves, and there they remain practically immovable.

---

[7] See A. C. Newell, *Wood and Lumber,* p. 67.

[8] See R. S. Morrell, and A. de Waele, *Rubber, Resins, Paints, and Varnishes,* p. 90; or A. A. Kelly, *Expert Wood-Finisher,* p. 214.

[9] See Rodney Brace, "The Production and Manufacture of Shellac," Industrial-Arts Magazine, Vol. XI, No. 12, pp. 471, 472; and Vol. XII, No. 2, pp. 48-50; and No. 4, pp. 154, 155.

In one of these cells, later on, each female insect lays about 1000 eggs. Sometimes the lac may cover the twigs to a thickness of from ¼″ to ½″. The insects are not active and have little vitality, but they are so numerous at times while feeding gregariously with their bodies closely packed together, that they give a red color to the branches of the trees.

Trees can be inoculated from infested stems so as to produce crops either in late spring or late autumn. It should be noted, however, that individual trees are trimmed but once a year, generally in June or February.

Stick-lac is the name given to the incrusted twigs of even length after they have been gathered. The stems, which are thickly covered with the exuded and coalesced scales of lac, are gathered about the time that the feeding or sucking of sap stops and before the young insects hatch out; and in this condition they can be shipped or used to inoculate other trees. The spring crop is said to be used to a large extent for propagating purposes, and is not of as much importance for gathering for the market as is the autumn or winter crop. The color of stick-lac on the twigs varies from a dark red to a rather pale orange yellow. When they are used to infest new trees, the young insects come out of the cells, which form around the bodies of the mother insects, and move about until they find a place to attach themselves, and thus a new crop is started. When lac-dye was valuable it was important to gather the stick-lac before the departure of the young; for, after that time, the red fluid found in the cell of gum about the female insect's body disappears.

The stick-lac or gum-covered twigs that are broken into sticks of even lengths, and the particles which fall to the ground in fragments under the trees, are gathered at some place where the resin can be crushed. Frequently this is done in a mill similar to that used for breaking up grain. By sifting and sorting, the fragments of wood and the bodies of the insects are removed; and the crude lac, then called seed-lac, is washed in hot water. A purple or reddish dye, which was quite valuable before the recent discoveries in aniline and other coal-tar colors, is removed by washing and is known as lac-dye. This dye, at one time more valuable than shellac itself, was supposed to be the same as cochineal, but chemists finally discovered that it contains a different acid.

In manufacturing shellac the dried seed-lac is mixed with orpiment (arsenic sulphide) to the extent of 0.05 to 0.25 per cent, and also with varying small amounts of rosin, an adulterant that is much cheaper than shellac-gum and does not seem to be harmful up to 3 to 5 per cent, but which is very advantageous to the workmen because it makes the melting of the seed-lac much easier.[10] The mixture is then placed in long thin cotton bags, which are about the size of a baseball-bat, except that sometimes they are nearly 20 feet long. When the bags are heated over a charcoal fire and twisted in opposite directions by two men, the melted resin oozes out thru the meshes of the cloth and is scraped off and spread out over a large porcelain cylinder containing cold water. After cooling, the sheets of shellac are removed from the cylinder and stretched into thinner sheets several feet square in size.

While the resin is being squeezed from the bags some of it drops to the ground, and makes little flakes known as *button-lac.* The buttons are usually of a dark ruby color, and when sold on the market they frequently have from 10 to 20 per cent of rosin mixed with the shellac gum, thus cheapening it.

Garnet-lac is another grade which is sold in sheets, and is said to have had the shellac wax largely removed. This grade on the market, however, generally has from 10 to 20 per cent of rosin mixed with it to reduce the cost and to lower its fusion temperature. Garnet-lac is often made from the residue which will not squeeze out of the bags. The shellac-gum is removed from the impurities by the use of alcohol or sodium-carbonate solution; and, after filtering, the solvent is liberated, or acid is used to destroy the alkali.

---

[10] Percy H. Walker and Lawrence L. Steel, *Shellac,* United States Department of Commerce, Technological Papers, Bureau of Standards, No. 232, pp. 278, 279.

Stick-lac in its crude form is not pure shellac-gum,[11] and is said to contain about 66 per cent of lac-resin, six per cent shellac-wax, six per cent gluten, and eleven per cent coloring-matter. Shellac-wax is not soluble in alcohol and, if present in liquid shellac, is the cause of its turbid appearance.

145. Alcoholic Solutions of Shellac-Gum.—Wood-finishers purchase shellac-varnish ready for use. It is prepared in factories where the shellac-gum, also called shellac-resin, is dissolved, usually in denatured grain (ethyl) alcohol, or in wood (methyl) alcohol.

Formerly, wood-alcohol shellac was commonly used because it sold at a much lower price than shellac-gum dissolved in grain alcohol, which was expensive because of a high government tax. Wood-alcohol shellac is not much used at present because of its poisonous qualities, its strong disagreeable odor, and the difficulty in application. It sets so rapidly that brushing it on smoothly is almost impossible, especially when it is attempted by inexperienced workmen. This kind of shellac is not used in French polishing because it will not work smoothly under the rubbing-pad. Bleached shellac is not entirely soluble in wood alcohol.

Strong or high-proof denatured alcohol, such as the United States Revenue Bureau's formula No. 1, which consists of 100 gallons of 190° proof ethyl (grain) alcohol and five gallons of approved methyl (wood) alcohol, is necessary for dissolving shellac gum. The ordinary 160° proof ethyl alcohol, which is the grade frequently sold on the market, is not strong enough to dissolve shellac-gum satisfactorily. High-proof denatured alcohol, which is poisoned with five per cent of wood alcohol in the United States, is consequently the solvent commonly used in dissolving shellac-gum.

---

[11] See R. S. Morrell and A. de Waele, *Rubber, Resins, Paints, and Varnishes*, p. 89.

Denatured-alcohol shellac sets more slowly than that made with wood alcohol, and for this reason it spreads better with a brush. This mixture hardens sooner than that cut with wood alcohol and does not have its pungent smell which is so irritating to most people. Grain alcohol has a great affinity for water and easily absorbs it in damp weather. Very small quantities of water mixed with alcohol will cause a milky or turbid appearance; for this reason the alcohol used should be at least 190° proof, which is the same as 95 per cent pure. Great care must be taken to keep water out of shellac, because even a few drops which have fallen into the mixture will cause precipitation of some of the gum, and any measurable quantity will change the liquid into a slimy coagulated mass that is useless. If a brush is wet with water when it is put into the liquid shellac, it will cause the same trouble, running the mixture and making the brush unusable.

The proportion of shellac-resin to the alcohol solvent varies somewhat. A thick shellac-varnish which is sometimes called standard may be made by using the following:

5 pounds bleached shellac-resin or gum to the gallon of 190° proof denatured alcohol; or

4 pounds orange shellac-resin to the gallon of 190° proof denatured alcohol.

These proportions make a very thick shellac-varnish, and it will be necessary to warm and agitate the mixture considerably before such a large proportion of resin will dissolve. Some extra heavy shellacs are made in the proportion of 6¾ pounds to the gallon of solvent. The cutting of shellac-resin is a slow and difficult process, and is best left to experienced men who have proper equipment in factories.

Good grades of shellac-varnish sold on the market are supposed to have four pounds of gum to the gallon of denatured alcohol. The cheaper grades of liquid shellac are apt to be made of some of the poorer adulterated gums and contain less than four pounds or frequently only three pounds of shellac-resin to the gallon.

Most of the thick shellac-varnishes should be thinned before use. A mixture of two pounds of orange shellac or two and one-half pounds of bleached shellac is usually heavy enough for application on wood.

146. Effects of Metal Cans and Dust on Shellac-Varnish.—It is unfortunate that liquid shellac as prepared by the manufacturers does not keep well in metal cans. After a few months, shellac which is kept in metal cans gradually darkens. This discoloration in the case of white shellac becomes serious after two or three years, and can always be noticed in the contents of a tin can that has been opened but not used promptly. The dark color can sometimes be removed by the addition of a very few white crystals of oxalic acid to the shellac mixture. The use of oxalic acid in shellac-varnish is a very questionable practice, however; because, if there is an excess over that which is necessary to remove the discoloration in the shellac, the acid may bleach the stain under the shellac, or lighten the tone of the wood itself. Some manufacturers put up their product in glass bottles in order to avoid all discoloration that comes from contact with metal. Experts recommend that prepared shellac-varnish be kept away from strong light, and in a reasonably warm room during cold weather, in order to prevent settling of the resin.

If a can or bottle of shellac is not kept tightly corked serious trouble will soon follow, because the alcohol will evaporate very rapidly, and after a time the thickened residue cannot be thinned in such a way that the solution will spread properly under a brush. The most serious trouble that comes from leaving a shellac-can open, comes from dust which soon settles into the mixture. Every speck of dust that goes into an open can of either shellac or varnish means a speck in a finish after it is applied to a surface, and this speck can never be removed. Shellac-varnish that has stood open in a room for any great length of time is always ruined for wood-finishing.

147. Orange and White Shellac.—The natural color of most grades of lac-gum that have not been bleached is some shade of orange, the depth of tone varying with the grade. The best grades of orange-shellac are not as apt to be adulterated with resin as the bleached. If more than a rather small per cent of rosin is present in shellac-varnish, it will prevent the film from drying on a surface as hard as it should, leaving the finish tacky for a number of hours.

Orange-shellac when dissolved in alcohol makes a better varnish than white shellac, because a film made with it is stronger and more elastic; and, in addition to these good qualities, the gum and prepared mixtures keep better. Alcoholic solutions of orange-shellac do not depreciate in quality thru rather long periods of storage, and are far more stable than is the case with white-shellac solutions, which gradually deteriorate and become darker in color.

Orange-shellac is objectionable for many purposes on account of its color. Bleached or white shellac is made from the various orange or colored shellacs by several processes. The coloring-matter consisting of red lac dye can be removed by the use of various weak alkaline solvents. Sometimes the orange-shellac resin is boiled in a weak solution of carbonate of potash, melted under water, and pulled till it is white. Another process is to dissolve the gum in some alkali and pass a stream of chlorine gas into the mixture to bleach the shellac which is then melted under water and pulled when soft. Treatment with hypochlorite of soda or potash, and then neutralizing with sulphuric acid, followed by filtering and washing in an elaborate process is a commercial method.[12]

---

[12] See A. A. Kelly, *Expert Wood-Finisher*, p. 206.

Bleached shellac is sold on the market in a coarse granular or ground form in order to make it more soluble in alcohol. Sometimes it is obtainable in large hanks which keep to better advantage. The bleaching process reduces its solubility, leaves it in a condition so that it is very apt to deteriorate with age, and renders a spirit-varnish made with it less elastic than that made from the untreated orange resin. Bleached shellac dissolves in alcohol much more readily soon after it is manufactured. The gum gradually deteriorates with age or storage, and its solubility in alcohol is greatly reduced.

White shellac-varnish when spread on a surface produces an effect of great brilliancy and unequalled transparency. It dries very hard, however, and on account of its lack of elasticity, it is apt to crack if it is bent or exposed to unusual conditions.

148. Use of Shellac.—Spirit-varnishes made from shellac-gum in solution are used for many purposes, such as the woodwork of a house, including the floors and trimmings, the making of toys, furniture, and musical instruments, for sizing or stiffening straw hats, for many kinds of insulating in electrical instrument manufacture, for some kinds of waterproofing, for the making of leather dressings, and sometimes in the place of oil-varnish for an undercoat on willow, rattan, and paper-fiber goods.

It is often the most desirable material known to use as a first coating over close-grained or non-porous woods, and to size stained and filled work so that varnish or wax may be used successfully later on. Shellac-varnish is superior to other varnishes in nonpermeable qualities, because it almost hermetically seals up the pores of wood, closes up resin-ducts thereby preventing exudation from knots and pockets, and prevents the ‘‘bleeding’’ of stain into the final coats of varnish. Manufacturers of spar-varnish, however, object to the use of shellac undercoats, because shellac does not weather as well as these ‘‘long-oil’’ varnishes. Practical wood-finishers agree that it is unwise to use shellac under spar-varnish on all woodwork that is exposed to outdoor conditions.

Spirit-varnish made from orange-shellac gum and alcohol is used commonly by pattern-makers, and to some extent by other woodworkers. When a shellac-varnish is applied to dark-hued woods, it is quite common to use a mixture of orange and white shellac. Too much orange-shellac in such a mixture is apt to give an orange tint that spoils the natural hue of some woods or changes the color effect of the stain. For this reason white shellac is preferable for most finishes, especially for light tones.

Spreading shellac is one of the very most difficult operations the wood-finisher is called upon to perform. The alcohol in the mixture evaporates so rapidly from a shellac-film that it is almost impossible to avoid laps, streaks, and untouched spots unless one has had considerable skill and experience.

As a transparent filler or surfacer on woods without open pores, there is no other finishing-material equal to denatured-alcohol white shellac. When applied as a first coat to size wood, it is wise to dilute liquid shellac of ordinary strength, such as a mixture of four pounds of gum to the gallon of alcohol, by using about one-half alcohol and one-half liquid shellac. Two coats of thin shellac, with a slight sanding between the applications, will make a much better finish than one heavy coat; chiefly because it is much easier to spread thin shellac evenly, and also on account of the greater probability of covering every portion of the surface by going over it twice with a brush.

Shellac must be applied to wood with great speed by the use of a wet brush and spreading lengthwise of the grain. The operator should stand in a position from which he can see just what he is doing, thus avoiding laps, streaks, and uncovered places. Frequently, it is possible to place the object between the finisher and the light by shifting it into such a position that the freshly covered surface will show a bright gloss where it has been shellacked. Every portion of the surface should be covered with the brush while the coat is being put on, for after about one-half minute no touching up can be done satisfactorily. Attempts to retouch tacky shellac often cause trouble, as rough places will result which generally harm the finish more than uncovered spots do because these small areas will be covered over by later coats of finish and usually do not show unless an effort is made to repair them after the film has partially set.

149. Drying and Sanding Shellacked Surfaces.—Shellac dries hard, usually in about eight hours, ready for sanding with fine sandpaper. While two coats of shellac can probably be put on during one day, it is best that a full day should elapse between applications. Great care and fine sandpaper must be used when smoothing and cutting off the gloss of shellac films, especially when thin mixtures have been applied. If both the shellac coat and the stain are cut thru by careless sanding, it is very difficult to make a repair that will not show, Fig. 16. A thoughtless ignorant finisher with sandpaper in his hands can do more damage in a few minutes than an expert can repair in many hours.

150. Shellac-Washes.—Wash-coats of shellac are frequently used under paste filler in order to size the wood and keep the stain from raising with the filler when it is rubbed. Wash-coats are made of thin shellac in the proportion of one part of standard liquid shellac to seven or eight parts of alcohol. Mixtures as thin as one to ten are usually satisfactory under paste filler. The proportion of one to seven is considered best when using a four-pound gum compound for the liquid-shellac portion.

151. Methods of Making Shellac Spread More Easily.—Camphor-gum is sometimes dissolved in liquid shellac in the proportion of one ounce of camphor to a gallon of shellac in order to make the mixture spread more easily under the brush. Small quantities of camphor-gum are frequently put in spirit-varnishes made of shellac, sandarac, and mastic cut in alcohol.[13] A weak solution of glycerine and alcohol may be added to shellac-varnish. Its action is similar to that of camphor-gum because it retards the setting.

Venice turpentine may be added to shellac in the proportion by weight of:

1 part Venice turpentine,
10 parts shellac-gum.

For the ordinary liquid shellac, this means that about five ounces of Venice turpentine may be added to each gallon of prepared shellac-varnish. Venice turpentine also makes shellac spread considerably easier under the brush because it lengthens the time between the application and the setting of the film.

152. Effects of Moisture on Shellac.—Damp weather may cause trouble when spreading shellac on account of the affinity of alcohol for water. If the film has a greenish hue or is not transparent showing a turbid, cloudy appearance, the finisher should stop work until conditions are suitable. During rainy weather the shop-windows should be closed. If the room is too cold, shellac will not spread well. Thin shellac-varnish will, however, spread better in damp weather than will a thicker mixture. The effect of humid air on shellac can usually be seen if a finisher attempts to spread bleached or white shellac-varnish over a dark-colored wood, such as walnut, during damp weather. The shellac film is apt to turn white or yellowish white because the rapid evaporation of the alcohol changes the temperature of the surface enough to cause moisture to condense and leave light streaks where the brush has applied the shellac. As soon as the water in the film dries out, the proper color is almost always restored. If white shellac is mixed with a small amount of orange-shellac, or slightly colored with a spirit-dye, the discoloration from moisture is greatly reduced or is less obvious.

153. Good and Bad Qualities of Shellac.—A film of shellac is an excellent finish in several respects: it forms an unexcelled binder between filler and varnish coats; it does not show white when scratched; it seals the pores of fine-grained work satisfactorily; it is very transparent; it does not often cloud or darken wood appreciably; and it makes a hard surface which is a good undercoat for other finishes. It is the best surfacer known for preventing pitch from exuding from knots; but it may disintegrate after becoming damp, and become powdery and rough; therefore, it is not suitable for outdoor finishes.

---

[13] See Ch. Coffignier, *Colors and Varnishes*, p. 220.

All of the lac gums except garnet lac contain various amounts of shellac-wax, which is practically insoluble in alcohol.[14] In manufacturing bleached or white shellac, an attempt is made to remove the wax; and, as a result, only three to four per cent of this insoluble matter remains. If any shellac-wax is left in a shellac varnish, it may cause trouble after a coating of such an unpurified shellac has been spread over a surface. The wax can be separated out to a considerable extent by filtering the liquid shellac; the wax being removed in the alcohol, as it is usually insoluble. Moisture contained in bleached shellac-gum itself may also cause a milky appearance, sometimes showing this effect later on, especially on French-polished or rubbed-shellac surfaces.

Shellac, on account of its acid nature, is affected by various alkalies. Ammonia which is found in the air, especially when present in unusual quantities, soon reacts with a shellac film and decomposes it. A coat of shellac can frequently be removed by washing it with a strong solution of soap and water.

Shellac softens at a very low temperature and melts at a very moderate heat, this fact being shown by its manufacture. The heat of a charcoal fire causes the crude lac-gum to melt and ooze through the meshes of a cloth bag. A thin film or coating of shellac-varnish shows the same sensitiveness to heat, consequently articles of furniture that are finished with shellac, even tho covered with an oil-varnish, should not be placed near a fire nor left outdoors in intense sunlight. Films of shellac are apt to blister if they are heated much above ordinary room temperature.

---

[14] See R. S. Morrell and A. de Waele, *Rubber, Resins, Paints, and Varnishes*, p. 215.

154. Rubbing Shellacked Surfaces.—Every coat of shellac should be rubbed in some way before the next layer of finish is applied, the chief reasons for which are: (1) a more level surface is obtained by this operation, especially if sandpaper is used; and (2) a dull, rougher surface is produced which causes better adherence of the next coat of finish that may be applied. Shellac-varnish will stick to an unrubbed undercoat of shellac, however. Undercoats of shellac may be rubbed with very fine sandpaper, preferably using No. 3/0 or No. 4/0 in order that the finish may not be scratched and to prevent cutting thro the coats of shellac and stain thus producing light spots or streaks. The sandpaper may be held in the hand for sanding the edges, especially, or it may be bent over a very soft-faced felt or rubber block when used on large surfaces.

If the novice is careless or uses too much pressure on the sandpaper, he is very apt to do serious damage in a very short time. Beginners should be warned that spots and streaks cut thru stained and shellacked surfaces can not be repaired without much labor. Sometimes it will be necessary to remove the entire finish, and the whole surface which has been damaged by sanding must be refinished. Curved surfaces are sanded to the best advantage by the use of split sandpaper which is very thin and flexible.[15] Fine steel wool is also useful for rubbing between coats on irregular or curved surfaces particularly. Very light pressure should be used, because there is great danger of cutting thru the coats of shellac and stain, even when rubbing with the very finest grades of steel wool, such as No. 2/0, which is about as fine as No. 3/0 sandpaper, or even with the No. 3/0 grade which is still finer.

Rubbing with a standard mineral rubbing oil and pumice-stone on a felt pad is the best way to smooth the final coat of shellac if several coats are used. While water and pumice-stone may be used properly in rubbing varnish no water should be used in rubbing shellac.

---

[15] See Section 9, "Use of Sandpaper," p. 30.

155. Shellac Substitutes.—The high prices of good grades of shellac-gum and alcohol have suggested a number of shellac substitutes. During the World War several such mixtures were advertised and sold. Nearly all of these substitutes have been found to be much inferior to high-grade shellac-varnishes; consequently they have almost disappeared from the market. Not a single such substitute has been generally accepted to be as satisfactory as shellac, tho a few are still sold on account of their low prices.

Substitute shellacs are usually made by replacing part of the shellac-gum with some other cheaper resin such as rosin, manila gum, manila dust, or an artificial kauri gum, usually called French kauri. Common rosin, which is cheaper than most of the other resins, is practically completely soluble in alcohol, and is substituted for shellac-resin in various proportions up to about 50 per cent. For a cheap substitute, such a mixture of shellac-gum and rosin of the W-W, or water-white, grade is cut in denatured alcohol in the proportion of two and one-half to three pounds of resin mixture to the gallon of solvent. Some of the poorer shellac substitutes that have been offered on the market contain no shellac-resin at all. They have sometimes been made from a mixture of rosin and manila dust, cut or dissolved in a solvent largely of wood alcohol, which can be replaced in part by 25 to 33⅓ per cent of naphtha and acetone.

Shellac substitutes dry very rapidly because of the solvents used and, in general, do not spread as well under the brush as genuine shellac-varnish.

156. Selection and Care of Shellac-Brushes.—The solvents used in dissolving shellac-resin all evaporate very rapidly; therefore, it is best to use a large brush when applying shellac-varnish because of the rapid setting and drying of the film after it is spread on a surface. Much more rapid work can be done on a large surface by the use of a brush which is at least 4″ in width. For shellacking furniture and small articles the brushes should be from 2″ to 3″ in width. A large brush enables a finisher to dip up more shellac at a time, and he is less apt to try to work with a nearly dry brush, which is a serious fault because it causes streaks, laps, and uncovered spots, instead of an evenly covered surface. Touching up or rebrushing cannot be done skilfully enough so that it does not show; therefore, great care must be used in the application of shellac-varnish to prevent the setting of the film from one brush-stroke before the next is spread adjacent to it at its outer edge.

Brushes having the bristles set or vulcanized in rubber are the most satisfactory for use with shellac. It is also preferable to select brushes which have hard-rubber instead of tin ferrules, because tin is apt to discolor the shellac. It is possible to apply shellac-varnish with brushes set in glue and bound with tin ferrules, but such brushes do not last as long nor give as satisfactory service as fitch rubber-set brushes with rubber ferrules. Brushes having the bristles set in shellac cannot be used at all in spreading shellac-varnish, because the bristles will all come out of the ferrules in a short time. For applying shellac, it is best to select brushes having rather fine, soft bristles because they will leave an evener surface with fewer brush-marks.

Shellac cannot be brushed into the grain and then smoothed out lengthwise of the fibers of wood in the manner of applying wood-filler or even varnish. It must be applied quickly with a well-loaded brush, using quick strokes and light pressure, because this method of spreading shellac varnish reduces the number of air-bubbles that are always more or less troublesome. Shellac-varnish is very apt to pile up and be rough or too thick at the laps;

consequently, it is best to select a rather large, soft brush, and to apply the finish lengthwise of the grain only, using quick, light strokes. Fast careful work tends to prevent laps, which are the result of slow work, and the rapid evaporation of the alcohol solvent.

Brushes used in applying shellac-varnish should be cleaned very often in either wood alcohol or denatured alcohol; because, if this is not done, fragments of partly-dried shellac will work out of the bristles around the ferrule and the film on the surface where the finish has been spread will show specks. If the brush cannot be satisfactorily cleaned in alcohol, a paint-and-varnish remover may be used as a cleaning agent. Brushes which have had the partly dried and hardened fragments of shellac removed by washing in paint-and-varnish remover should be dried and then softened in alcohol in order to remove traces of the cleaning fluid from the bristles before putting the brushes back into shellac again.

Shellac-brushes should never be washed or soaked in either water or turpentine. Water will cause serious trouble as has already been mentioned in this chapter. Some finishers make a practice of washing all brushes in soap and water after they have been thoroly cleaned. If this is done, the brushes must be allowed to dry thoroly before returning them to the shellac-container.

Brushes used in shellac-varnish should be cleaned daily, and kept suspended in a tank of alcohol or very thin shellac-varnish when not in use. If allowed to dry over night after being cleaned, they always become somewhat stiff. This stiffness usually disappears, however, if the brush is soaked in alcohol for a few minutes before it is used in shellac-varnish again.

157. French Polishing.—Before the discovery of methods of making oil or oleoresinous varnishes, French polishing was often used in finishing articles of furniture when a surface having a high polish or brilliant, glossy effect was desired. In those days there was no commonly known method of applying a varnish to a surface with a brush. It is supposed that possibly some of the famous violin-makers did have secret methods of making varnishes from amber and other high-grade resins, and that these finishes were used to a limited extent long before our modern oil-varnishes were known. The old-time finisher had few choices in his materials, and usually was compelled to choose an oil-finish, a wax-finish, or a French polish.

French polishing has almost disappeared from among modern finishing methods, largely because of the slowness of procedure which is necessary, and the large amount of labor which is always involved. In addition to these serious objections, French polishing requires much skill, and is really a job for an expert. French polishing is really an antiquated process, which is rarely used by wood-finishers of the present day, and is almost a lost art. Occasionally, a student or amateur wood-finisher in the home or shop has some article or furniture, such as a red cedar chest, or a table made of some foreign wood, which he wishes to finish in natural colors with a brilliant, lustrous effect. Such work can be done at odd times, and the cost of the labor involved is not considered.

Several procedures are possible in French polishing. The method is not often attempted on open-pored work, such as oak or chestnut. In case such woods are to be finished with French polish, it is best to stain and fill the surfaces before any polishing with a rubbing-pad is attempted.

A filler in its natural color will darken any wood to a certain extent on account of the linseed-oil which is an ingredient of the filler itself. French polishing is more commonly attempted on close-grained woods such as red cedar, or diffuse-porous woods having small tracheal vessels or, in other words, rather inconspicuous pores, such as those of mahogany or walnut.

Various mixtures of thin shellac are recommended for French polishing. Sometimes the following is used:

6 ounces orange or white shellac-gum,
1 quart denatured alcohol—190° proof, formula No. 1,
½ ounce Venice turpentine.

The mixture should be stirred or churned for a number of hours before use. The Venice turpentine is supposed to add durability and toughness to the film and make the solution easier to apply with the rubber. Shellac-gum is not commonly kept among the supplies in a present-day shop; therefore the old formula may be stated in a more convenient form as follows:

1 pint prepared denatured-alcohol shellac-varnish,
3 pints denatured alcohol—190° proof,
¾ ounce Venice turpentine.

Sometimes, raw linseed-oil is substituted for the Venice turpentine. These substances are used for their lubricating qualities. Linseed-oil is only partly soluble in alcohol and is very largely removed by the spiriting-off process at the end of the polishing operation. Bleached linseed-oil is preferable if one wishes to keep the wood in its natural color.

Another shellac mixture for French polishing that is preferred by some finishers is as follows:

4 ounces prepared denatured-alcohol orange or white shellac-varnish,
1 quart alcohol (denatured)—190° proof,
1 ounce benzoin gum,
1 ounce poppy oil.

If the mixture is to be used on woods which have pronounced hues, color that is made from spirit-soluble coal-tar dyes should be added, using Bismarck Brown for mahogany, and Bismarck Brown with more or less spirit-soluble black or even a touch of Methyl Violet to give less deadness to the tone whenever dark brown is desired. Bismarck Brown, which is much more red than brown in tone, can be grayed as desired by the addition of a complementary color, such as Victoria Green, Malachite Green, or any of the spirit-soluble greens. The wood-finisher should always be very careful about coloring shellac, using as little stain as possible, because most of the coloring-matter will remain above the surface and obscure the grain of the wood to a certain extent.

French polish is applied with a rubbing pad rather than with a brush. Many experienced finishers prefer a cone-shaped pad, made by winding strips of clean muslin into a conical form of about 3″ or 3½″ in length, and 1″ to 1¼″ in diameter at the base. The covering for the rubbing-pad is made of linen, or rather of fine lintless cotton cloth, about the size of a man's handkerchief. The cone should be well wetted with the shellac mixture and covered by the cloth. A good way to wrap the cone in the cover cloth is to place it near the middle, fold over the end of the cloth back to the point of the pad, and then fold and gather the excess cloth about the back of the cone but at one side of it.

In applying the polish some finishers dust a small amount of fine pumice-stone over the surface to be finished, and this material is then rubbed into the pores as a filler. The pad is always used with circular motions, gradually covering the entire surface. On close-grained woods no pumice-stone is used as a filler, the shellac itself being rubbed on the surfaces and into the pores. Mixtures for French polishing which contain oil can frequently be rubbed over the surfaces without coating the surface of the pad with raw linseed-oil. The rubbing-pad requires the addition of more shellac from time to time as the surface of the wood absorbs the polish. Many coats of the thin shellac-varnish are necessary for the successful French polish. The finished surfaces should always be allowed to dry from a half hour to two hours between coats. Each coat of polish needs to be slightly smoothed or cut off with very fine sandpaper, No. 6/0 to No. 8/0 sizes. It is usually more satisfactory to use thinner shellac for the last coats than for the undercoats. All that is necessary is to thin the polishing mixture with more denatured alcohol.

The final "spiriting-off" process removes any small roughness or ridges that may be left in the polishing processes. A rubbing-pad that has only a little shellac in it should be used. The surface of the pad is moistened with pure 190° alcohol, and the polishing is continued with circular strokes over the entire surface. Somewhat smoother results can often be secured by making the circular motions with the pad in the direction opposite to that used during the earlier applications of the polish. The finisher should be very careful not to use too much alcohol on his pad, or much of the polish that has been applied previously may be removed. The "spiriting-off" process removes any excess of lubricating oil and smoothes the surface leaving a very clear, and beautiful finish having an exceptionally high luster.

Polishing with shellac on a lathe is a modified form of French polishing that is often used in school shops. For polishing in the lathe, a "rag" or piece of cloth is substituted for the rubbing-pad which is used on flat surfaces. Cotton-waste is recommended by some teachers, but it is apt to catch and wind up on spindle turnings and is not satisfactory for that reason. A rather stout, smooth cloth that is lintless and torn to a size 2″ or 3″ wide by 12″ to 16″ long makes a good "rag," that can be held against a spindle on the lathe with one hand at each end of the cloth, thus securing the proper pressure and avoiding the danger of catching and winding up. The mixture of shellac is similar to that already suggested for French polishing. The following formula has been found satisfactory:

1 ounce denatured-alcohol white shellac-varnish,
4 to 5 ounces denatured alcohol,
1/10 ounce linseed-oil (raw oil preferred).

A number of coats of thin shellac are needed in order to fill the pores of wood properly and build up enough thickness of film to give a good gloss to the wood when the mixture is applied with a "rubbing-rag." Some finishers use a slightly thicker shellac mixture for the first few coats, and a thinner or weaker polishing shellac similar to the formula suggested for the last few coats. From six to ten coats of thin shellac are required in order to furnish a satisfactory finish. In polishing with a shellac rag, the lathe should be run at about its slowest speed, and the cloth, moistened in the middle, should be stretched between the two hands and the shellac applied in this way. The finisher should keep the rubber moving constantly, in order to spread the polish and keep it from piling up in ridges or rings. More of the thin shellac must be placed on the cloth from time to time as the polish is drawn off from the rubbing-rag to the wood. The last operation should be a polishing or "spiriting-off" with 190° proof alcohol alone, on an old polishing-cloth that has some shellac in it from previous use. The cloth should not be soaked with alcohol for the finishing process, or much of the previously-applied film of shellac may be removed. Careful work with a polishing-rag, dampened with alcohol and kept in motion along the piece being polished while the lathe is in motion, will smooth a surface and give it a beautiful gloss. In addition to smoothing the surface, the clear alcohol removes most of the linseed-oil which was mixed with the shellac for the purpose of lubrication. The removal of the oil improves the luster and imparts to the smooth film of shellac a more brilliant gloss.

Rubbing-varnish which has been thinned with from three to five parts of turpentine can be used with a "rubbing-rag" on the lathe just as thin shellac is used. The coats of varnish take much longer to dry than is the case with each film of shellac. Each of the thin films of varnish adds more body to the finish than does a coat of shellac, and should have about 24 hours for drying, while the shellac finish requires only from one-half hour to an hour for hardening between applications.

REFERENCES—CHAPTER XI

Spirit-Varnishes

J. Gauld Bearn, *Chemistry of Paint, Pigments, and Varnishes,* Chapter XV, pp. 167-9; "Spirit-Varnishes," Chapter XIX, pp. 232-3.

Berry Bros., *Varnish-Gums, Varnishes, and Varnishing,* p. 3, pp. 16-20.

Bulletins No. 5 and No. 6, Grand Rapids, Wood-Finishing Co.

Rodney Brace, "The Production and Manufacture of Shellac," Industrial-Arts Magazine, Vol. XI, No. 12, December, 1922, pp. 471-2; Vol. XII, No. 2, February, 1923, pp. 48-50; and No. 4, April, 1923, pp. 154-5.

Ch. Coffignier, *Colors and Varnishes,* Chapters XIII, XIV, pp. 214-228; "Gums," Chapter II, p. 133.

G. B. Heckel, *A Varnish Catechism,* p. 14. (National Varnish Manufacturers Association, No. 634, The Bourse, Philadelphia, Pennsylvania.)

Fred T. Hodgson, *Hardwood-Finisher,* "French Polishing," pp. 66-93.

A. A. Kelly, *Expert Wood-Finisher,* "Shellac Varnish," pp. 203-224; 242-3.

A. J. Kirst, "The Shellac-Rag for French Polish," Industrial Education Magazine, Vol. XXV, September, 1923, p. 73.

H. R. Jeffrey, *Wood-Finishing,* pp. 49, 83-97.

F. Maire, *The Modern Wood-Finisher,* pp. 73-81, 122, 3.

R. A. McGee and A. G. Brown, *Instruction Units in Wood-Finishing,* pp. 22-8.

R. S. Morrell and A. de Waele, *Rubber, Resins, Paints and Varnishes,* "Spirit-Varnishes," pp. 213-18; "Spirit-Varnish Resins," pp. 87-90.

A. C. Newell, *Wood and Lumber,* "Turpentine," p. 67.

Wm. Noyes, *Hand Work in Wood,* pp. 215-16.

G. M. Nyman, "Staining and Varnishing," Industrial-Arts Magazine, June, 1923, Vol. XII, No. 6, p. 231.

E. Perry, *Varnishes, Driers and Drying-Oils,* p. 48.

Allan Rogers, *Manual of Industrial Chemistry,* Chapter XXXIII, p. 696.

A. H. Sabin, *Technology of Paint and Varnish,* pp. 132-140, 317-18.

W. K. Schmidt, Furniture Manufacturer Magazine, May, 1923, p. 209.

W. K. Schmidt, *Problems of the Finishing-Room,* "Production and Adulteration," Chapter LV, pp. 289-297.

F. H. Thorp, *Industrial Chemistry,* "Shellac," p. 360.

Percy H. Walker and Lawrence L. Steele, *Shellac,* United States Department of Commerce, Technological Papers of the Bureau of Standards, No. 232.

F. N. Vanderwalker, *Wood-Finishing, Plain and Decorative,* Chapter XIII, pp. 153-175; 231-2.

CHAPTER XII

ENAMELS AND ENAMELING

158. Paint-Enamels and Their Functions.—The term enamel is loosely used in naming various compounds which usually contain paint, pigment-colors, and varnish. The word may also refer to fused enamels sometimes called glazes. Paint-enamels are sometimes called varnish-paints or colored varnishes. In this chapter the word enamel refers to paint-enamels exclusively. Enamels are generally defined as being either pale air-drying or baking varnishes which contain white paint-pigments and very often coloring-matter. Color in paint-enamels usually comes from pigments which are ground in varnish, oil, or japan; but in some cases it may be derived from coal-tar dyes. For white enamels the very best French-process zinc white is the pigment that is most satisfactory, and it is ground in a special very pale or transparent varnish. See Fig. 17.

Enamels possess good body, and this means opacity or power of obscuration which is commonly called covering-power. In general, however, they do not have the opacity of oil-paints. Enamels are very tough and elastic, and usually wear far better than oil-paints under similar conditions. Many of them are made with a high gloss which resists very severe exposure, others have semigloss or dull effects.

The drying time for enamels is similar to that of oil-varnishes, being from 12 to 18 hours as a general statement.

The chief function of enamels is to give a very high-grade finish which is hard, smooth, and long-lasting for inside use and resistant to weather when used outside. Enamels are primarily finishing materials, not undercoating substances. They are used for the last one or two finishing coats only, on account of their great beauty and good wearing qualities and their superiority to paint.

159. Composition of Enamels.—The ingredients selected for the manufacture of enamels are rather numerous, because of the many uses to which enamels are put and the grades and types that are in demand.

The pigments used in enamels are ground very fine, in varnish, preferably, and sometimes in linseed-oil or in

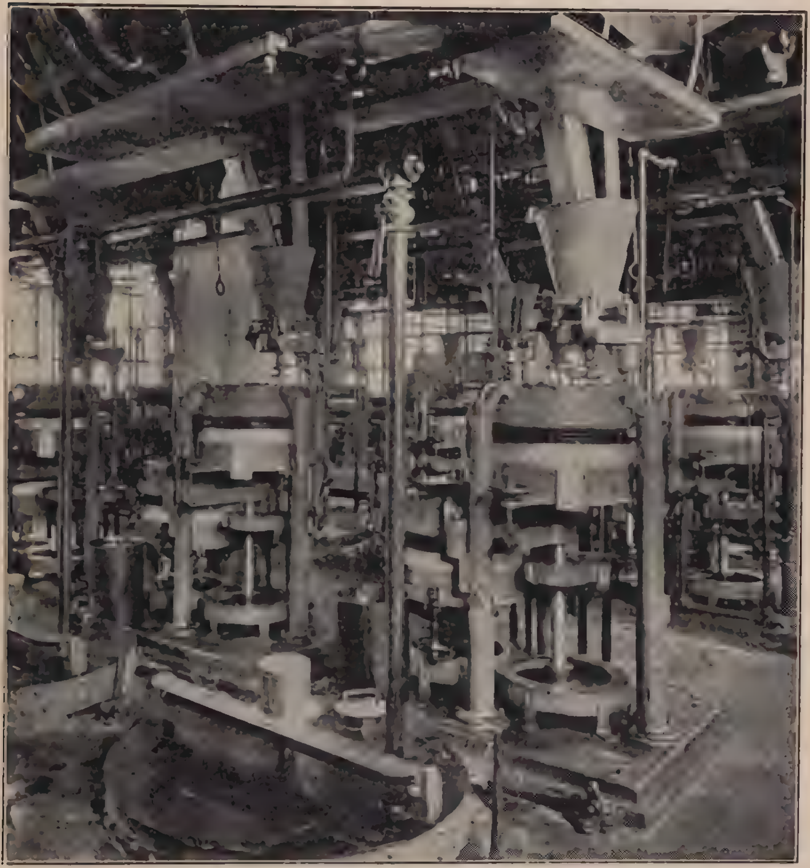


FIG. 17—ENAMEL GRINDING MILLS

The pigments that are used in manufacturing enamels are ground in special enamel varnishes in large mills that are called grinding mills. Courtesy of the Sherwin-Williams Co.

japan. In the case of white enamels of high grade, only the very best French-process zinc white of the green or white seal grades is used, and it should be ground in a very transparent or pale enamel-varnish. Zinc white (ZnO) is selected because it is somewhat whiter than white lead, which is a hydrated carbonate of lead having the formula —$2PbCO_3Pb(OH)_2$. It is also preferable because it can be ground to great fineness. Zinc white readily unites with the varnish-resins, and has certain desirable physical characteristics which are beneficial in the application of the enamel by making it flow on the surface more satisfactorily. It is not wise to use zinc white ground in ordinary linseed-oil when making white enamel, because linseed-oil frequently turns somewhat yellow on long exposure and this discoloration spoils the snow-white effect of the finish.

Many manufacturers use an elastic, long-oil varnish as a vehicle, even in the production of white and ivory enamels. The varnishes selected for this purpose are special enamel-varnishes, however, and are almost transparent because they are made from pale resins and bleached linseed-oil. Until rather recently zinc white was used almost exclusively as the pigment to give opacity to enamels. Lithopone, which is about 70 per cent barytes ($BaSO_4$), together with zinc sulphide (ZnS) varying from 26.60 to 29.51 per cent, and zinc oxide (ZnO) in small amounts of from 0.57 to 3.30 per cent, is now made in pure form—free from other metals which tend to discolor it. Lithopone is often used with zinc oxide in many of the cheap enamels, especially.

The medium or vehicle for carrying the pigments in enamels is usually some very pale or transparent varnish. For white enamels a good grade of dammar-varnish formerly was selected for the purpose, but new films made from it are more brittle, being rather markedly less elastic than those from the best of the pale oil-varnishes. Some American manufacturers have used dammar-varnish, because it produces the whitest and probably the most satisfactory snow-white enamel known, and one that contains little or no linseed-oil which tends to discolor with time and turn slightly yellow.[1] Pale rubbing-varnishes produce superior wearing surfaces and are often placed in enamels of the glossy type, especially, and are helpful where a rubbed finish is desired. The slight discoloration from the linseed-oil in such varnishes is not seriously harmful with most of the colored enamels. Attention should be called to the fact, however, that oxidized linseed-oil in a paint-film shows slow and progressive disintegration, which becomes much more rapid after the dried coating has reached its maximum weight.

The marked physical changes, of course, are the result of chemical changes in the oil itself that follow the absorption of oxygen. In this case the linseed-oil loses its power of cohesion to a great extent, and its function as a binder for the pigments ceases to exist. Crumbling, disintegration, and scaling of a paint-film gradually follow when the particles in the mass of the coating are no longer held firmly together by the adhesiveness of the binder. In enamels, however, it should be remembered that varnish instead of linseed-oil is used as a medium or vehicle for carrying the pigments.

The inclusion of varnish-gums greatly increases the adherence of the particles of pigment in the enamel. If the pigments are ground to very great fineness and mixed in a proper varnish medium, a condition that is somewhat colloidal is the result. Zinc oxide is a very active basic material; and, when it is finely ground and used with varnishes which contain rather thickened and somewhat acid oils that possess high viscosity, a colloidal mixture which produces a film of enamel of great stability and permanence is the result.

Where oil-varnishes are used the gums that react to best advantage with the basic zinc are strongly acid resins rather than those which possess a low acid value or are neutral in reaction. Some of the cheaper enamels contain specially treated rosin in the varnish with which the pigments are mixed. Rosin is not durable, but has a rather fine luster and is placed in enamel-varnishes at times entirely on account of its cheapness, and never because it is better than or the equal of more expensive long-wearing varnish-resins.

---

[1] See Berry Brothers, *Varnish-Gums, Varnishes, and Varnishing*, p. 21.

The best volatile solvent and thinner to use in enamels is undoubtedly American gum turpentine, called spirits of turpentine or oil of turpentine. If too much turpentine is added to a prepared gloss enamel in an attempt to thin it, some of the high luster will be lost and a flatting effect will result. Some manufacturers sell a specially prepared enamel reducer which is apt to consist of a large per cent of turpentine with a small amount of the same varnish-gum used in the enamel. The resins used are either dammar, or some pale copal, or other transparent oil-soluble gum. The prepared reducers are therefore nothing more than thin varnishes which can be mixed with gloss enamels, particularly, without loss of luster. The opacity or covering power of a coating which is made of thinned enamel is, of course, reduced.

On account of the high price of turpentine, other thinners are often substituted, such as benzine, and sometimes small portions of benzol; also toluol, which is closely related to benzol, both being coal-tar derivatives. Acetone is another volatile thinner which is occasionally used in enamels. If only a comparatively small amount of thinner is needed, most wood-finishers add turpentine. A less expensive thinner may be made of equal parts of turpentine and benzine. It is poor economy, however, to use very much benzine for the reason that this liquid does not have a very strong solvent action on dammar or oil varnish-gums. Benzine does not have the flatting effect on gloss enamels that is objectionable in turpentine; therefore, it is preferred by some finishers, especially where it is desired to preserve a high luster on a surface.

Coloring or tinting of enamels is accomplished by the addition to the zinc-white pigment of finely ground colors which are apt to be mixed with a specially prepared pale enamel-varnish. White enamels, which are already prepared, may be mixed with properly prepared colored pigments, or they may be colored by compounding them with colored enamels. If a finisher knows how to mix colors, he can obtain any desired hue by mixing together prepared colored enamels, or by adding the proper amounts of colors which are ground either in japan, oil, or preferably in a special enamel-varnish.[2]

TYPES OF ENAMELS

Several surface effects or types of finish are needed in enamels. The manufacturers have met these demands, and are now producing enamels having high-gloss, semi-gloss or egg-shell gloss, and flat or dull effects. These names refer to about the same surface appearances as those produced by varnishes having similar names.

Other properties of enamels besides surface effects are taken under consideration in the manufacture of enamels, and this has resulted in quite a variety of names for the various products, among them being: polishing enamels, marine enamels, exterior enamels, satin-finish enamels, rubbing enamels, egg-shell or semi-gloss enamels, and flat enamels. The user of enamels soon discovers that enamels which are given similar names by different manufacturers are not all alike in composition and vary somewhat in characteristics.

160. Gloss Enamels.—Gloss enamels vary in composition, the ingredients selected depending largely upon the use for which the finishing-material is intended. For example, white refrigerator enamels and some other snow-white enamels occasionally contain a pale, hard Batavia A or B or other similar high-grade dammar resin, which produces the most brilliant gloss or luster that comes from any of the varnishes used in manufacturing enamels. Dammar-varnish is a spirit-varnish which is made with a turpentine solvent, usually, and contains no linseed-oil which at times turns to a yellowish tinge after aging. The pigment which is mixed with the pale, very transparent dammar-varnish is zinc white for all white and very light-toned enamels. Other oil-soluble pigments may be used with enamels of dark hues.

---

[2] See Chapter VII, "Colors and Wood-Stains," p. 78; and Table IV, "Coloring Natural Paste Fillers with Pigments Ground in Oil," p. 146.

An enamel with a composition similar to that just mentioned can be used for a *baking enamel,* if a temperature of not more than 180° F. (about 82½° C.) is used within the limits of four to six hours in an oven. Enamels which can be baked on surfaces usually wear much longer, being harder and tougher, and not easily softened by water or oil.

Other gloss enamels are made from very pale oil-varnishes containing specially treated drying-oils. Gloss enamels of such compositions are very durable, being unusually water-proof, and suitable for use in most of the rooms of a house, but especially for kitchens, bath-rooms, and in such places as dairies, ice-cream plants, and parts of hotels, hospitals, and restaurants where much water is used, or where the woodwork is exposed to repeated washings or much dampness.

While gloss enamels are intended for use on the inside of buildings, they wear well on the outside, and may be mixed with gloss paint thereby producing a coating that is unusually lustrous, hard, and durable. When gloss white enamel is mixed with outside white paint a very much whiter effect is produced than with white paint alone. For outside use, gloss enamel of the type made from an oil-varnish is very durable, and stands the weathering effects of smoke, sand blown by the wind, sleet, rain, snow, and sunlight. Many manufacturers who use a long-oil varnish medium in their gloss enamels make no distinction between gloss enamels and polishing or rubbing enamels.

161. Polishing- or Rubbing-Enamel.—A polishing- or rubbing-enamel, which is often called a gloss enamel, produces an effect which is similar to that of the gloss enamel just described, the varnish medium being made from a light-colored carefully prepared rosin or a very pale copal gum, a solvent of turpentine or turpentine substitute, and a vehicle of specially treated boiled linseed-oil, sometimes called "stand-oil," particularly by English writers. Some of the varnishes used are long-oil varnishes which contain bleached linseed-oil prepared in such a way thru heat treatments and the addition of driers that it is almost colorless and darkens the zinc-white enamel body but very little.

Some of the well-known enamels evidently contain specially treated tung-oil or China wood-oil, which replaces at least part of the linseed-oil usually contained in pale oil-varnishes made for use in enamels. Polishing- or rubbing-enamels usually dry hard in from 24 to 48 hours. If two coats are used, the surface is carefully sanded with No. 3/0 or No. 4/0 sandpaper after the first coat, in order to produce a smooth surface, and to remove the gloss which is apt to prevent the last coating of enamel from adhering properly to the one previously applied. Polishing gloss enamels can be rubbed with pumice-stone and water, which produces an effect similar to that which comes from a rubbed varnish finish.

162. Water-Proof Enamels.—Water-proof enamels, also called marine enamels, are used for finishing parts of boats, water-pails, sinks, bath-tubs, bath-rooms, kitchens, special hotel-rooms and other portions of buildings and utensils which are often used in or about water. If made from high-grade varnish that contains no rosin, such enamels can be used with both hot and cold water, but they are improved by being properly baked on the surfaces instead of being dried at ordinary temperatures.

163. Exterior Enamels.—Exterior enamels are made from long-oil varnishes which dry slowly. They stand the weather more satisfactorily than other enamels on account of their greater elasticity. They are sometimes used on the outside of buildings or portions of buildings which require superior lasting finishes and also on porch and camp furniture.

164. Satin-Finish Enamels.—Satin-finish enamels, also called egg-shell or semigloss enamels, have an attractive appearance with a dull polish similar to that produced on ivory or horn, but with less luster. The final effect of these enamels is much like that of a hand-rubbed finish with pumice-stone on a gloss enamel. They are very popular for the trimming or interior woodwork of buildings and furniture on account of the soft effects produced, including a sheen or dull luster that is artistic and very attractive. This type of enamels should not be used for exterior surfaces, because they are made from a short-oil varnish medium and do not wear as well outdoors as do gloss enamels.

165. Flat Enamels.—Flat enamels are made in a manner similar to that used in manufacturing gloss enamels; but, in order to reduce the gloss, less of the transparent or pale varnish is placed in the vehicle, and more turpentine with its flatting qualities replaces it. Flat varnishes are made by some manufacturers from a soft East India gum by the "slack-melting" process, which requires only from 150° to 175° F. of heat for melting the resin, instead of 550° F. required in the manufacture of rubbing-varnishes from Congo gum, and are said to be used as a vehicle in the manufacture of some of the very dull enamels which have practically no gloss.

The pigments used in flat enamels are zinc white and lithophone, which are ground very fine. Lithophone tends to dull the luster of enamels containing it. The luster of flat and satin enamels varies with the amount of varnish used; that is to say, the more varnish used the greater the gloss. Flat enamels have only enough varnish in the medium to hold the particles of pigment together and act as a binder. In enamels, the amount of linseed-oil is limited; or omitted, if dammer-varnish is used; and the varnish itself acts as the cementing material which causes the very finely ground particles of pigments to cohere or hold together when a film of the mixture dries after being spread on a surface.

166. Durability of Enamels.—Enamel finishes, while expensive, are very attractive and beautiful because they are always used as final finishes over carefully prepared foundations of undercoats which are invariably sanded in order to level the surfaces before the next application or coating. The chief reason for using an enamel finish is that it has great durability. Such finishes, if properly applied and made from high-grade materials, are enduring because the surface films do not dry up into powder and rub off in the form of dust or scales as paint does.

An enamel finish is as enduring as a varnish finish, the lasting qualities varying, however, with the grade of varnish which is used as a medium. The cheaper enamels are, of course, made from less expensive materials and the cheapening is apt to come from the use of inferior varnish, which is often made from low-priced gums such as colophony, a high-sounding trade name for rosin manufactured from crude turpentine gum. Enamels that include varnishes having much rosin in their composition are usually very brittle, and cannot stay in place over a wood surface that expands and contracts to some extent with the varying moisture conditions of the air. The lack of elasticity of such an enamel causes checking, cracking, and scaling off, and the result is a ruined finish.

For exterior use, a gloss enamel that is rather slow in drying, because there is more drying-oil in its composition, is preferable unless a snowy whiteness is wanted Drying-oils, such as boiled linseed-oil and tung-oil, retard the speed of drying and may cause a slight yellowing in white enamels; but they add greatly to the elasticity of the vehicle, and reduce the brittleness of the enamel itself after it has been dried on a surface in the form of a film.

167. Undercoats and Preparation for Enamel Finishes.—The beauty and wearing qualities of an enamel finish depend partly on the quality and handling of the enamel itself; but also, to a large extent, upon the foundation of undercoats which may be either helpful or ruinous to the final outercoatings. The number of undercoats in enamel finishes of the highest class may vary from one to ten. Most enamel finishes, however, have from three to five or six undercoats.

The obscuration of the wood itself, and a proper tone effect of color, should be completed by the undercoats: (1) because the opacity or covering power of enamels is less than that of paints; and (2) for the reason that not more than two coats of the final material are used, largely on account of the expense, and partly because it is more difficult to make enamel films adhere to gloss enamel than to undercoats of flat paint. Exterior gloss paint is unsatisfactory under enamel for two reasons: (1) because such paints contain too much linseed-oil; and (2) because enamels do not adhere well to glossy undercoats.

Woods that are to receive an enamel finish should be carefully prepared by the same methods used for varnish finishes. In other words, they should be planed, scraped, sanded, and dusted. All holes should be plugged or filled with cabinet-maker's cement. Oil putty should not be used until one coat of paint has been applied to the surfaces. Metal surfaces are best cleaned with benzine or cleaner's naphtha which will remove any oil or greasy spots and dirty places that might prevent the proper adherence of the undercoats. Rusty places on metal must be brightened by sandpaper.

168. Enameling Specifications and Procedure.—Specifications and directions for an *enamel finish of six or seven coats* are as follows:

1. A coat of about *one-half strength shellac-varnish* should be applied over all knots and spots containing pitch especially. Woods that are quite porous or absorptive of finish should have a coat of shellac over all the surfaces to be finished, in addition to the shellacking for knots and

pitch. Some finishers prefer to apply shellac over the first priming-coat of paint. Both methods generally give entire satisfaction if the film of shellac is properly sanded with No. 2/0 or No. 3/0 sandpaper, in order to remove the gloss before the next coat is applied. A shellac sizing-coat should be used on yellow pine, basswood, and cypress, but is not necessary for such woods as poplar or birch. If the finish is to be of white enamel, it is preferable to use white shellac, otherwise orange shellac should be selected.

2. A *priming-coat* of properly colored paint, made by the use of white lead, pigment-colors ground in oil, and a vehicle of equal parts of boiled linseed-oil and turpentine, should be applied over the shellac sizing. Some finishers prefer to use raw linseed-oil and japan drier instead of boiled oil. If the priming-coat is for a white-enamel finish, no color should be used, and as little linseed-oil as possible.

Usually, a mixture for a priming-coat under white enamel should be made of one-third boiled linseed-oil and two-thirds turpentine. In order to prevent linseed-oil from working up thru the undercoats and turning white enamel to a slight tinge of yellow later on, some experts apply the sizing-coat of shellac over the priming-coat rather than under it. It is preferable to obtain a pale or bleached linseed-oil and a white japan drier, if possible, especially for use under a white-enamel finish. The ground-coating of paint should be spread as smoothly as possible, and two days should be allowed for drying if the mixture is made with boiled linseed-oil, and usually three days if raw oil is used. After the paint is thoroly dry it should be smoothed with No. 0 or No. 00 sandpaper, and the surface should be dusted. If puttying is required the sanding operation should be delayed until the putty is dry.

3. *Puttying* should follow the priming-coat of paint. Oil-putty, which can be purchased in light and dark colors, should be used. Putty can be prepared in the shop by mixing a factory-made paste of lead in oil with dry whiting until a stiff putty is obtained. Pigments known as dry

colors should be kneaded into the putty if colors are wanted. A small amount of japan drier can also be added to the mixture to make a quick-drying putty.

In the application of putty a finisher should use a putty-knife and fill all holes, cracks, worm-holes, and dents or other defects, and the filling should be done generously, so that all openings shall be overfilled rather than underfilled. The putty itself does not shrink much if any in hardening. The excess of material is easily removed flush with the surface with sandpaper after it is thoroly dry, and presents much less of a problem than an underfilled hole. Putty should be allowed to dry for 24 hours or part of it may be pulled out of place by the brush when the next film of undercoat is spread over the surface.

4. *Flat-paint undercoats* should be applied over the priming-coat, or over the shellac-film in case the latter is spread over the priming-coat, as is sometimes done. Two or three applications of undercoating paint are generally used, the number depending upon the perfection of finish desired. Special enamel undercoat paints can be purchased of paint-dealers, and these should be tinted or colored with colors ground in japan in order to match the tone of the final enamel hue or effect.

It is not desirable to use linseed-oil in the last application of undercoat paint, turpentine being the proper thinner. Undercoats may be prepared in various ways. Some finishers use white lead ground in oil, taking one part of boiled linseed-oil and three parts of turpentine for the first undercoat. The last undercoat should consist of equal parts of zinc white and white lead ground in oil, thinned with 3 parts of turpentine, and one part of white enamel-varnish. The enamel-varnish may be omitted, and turpentine alone can be used as a medium and thinner.

Dammar-varnish is sometimes used as an enamel-varnish. Pale oil-varnishes are preferred by many finishers because of greater elasticity and permanency. If three undercoats are applied, the second one should contain very little or no linseed-oil, and should be much like the last undercoat just described.

Each application or film of the undercoating paint must have approximately three days to dry, and should then be smoothed down with No. 0 or No. 00 sandpaper, and dusted before the next coat of paint is brushed over the surfaces that are to be enameled. Some paint undercoats, under good drying conditions, will dry hard in two days. The speed of drying depends upon the temperature and humidity of the atmosphere and varies from day to day.

Lithopone, a rather new snow-white pigment of unusual opacity and covering-power, is recommended by at least one manufacturer of wood-finishing supplies for use as an undercoating paint. For some purposes lithopone paint may be used with satisfaction. It has some advantages: such as, low cost because it usually sells at about one-half the price of zinc white or white lead; it is non-poisonous, making it a very safe paint for toys; it has low oil absorption, and greater whiteness than is possessed by white lead; and it also has greater opacity than any other white pigment.

On the other hand, there are some serious objections to its use in certain places and under certain conditions. Lithopone paints do not weather well, and such paint-films soon become chalky and flake off from the surface; consequently, they cannot generally be used for outdoor work. Some of the newer lithopones are said to be fast to light and satisfactory for exterior work.[3] Most of the lithopone paints used in the past have darkened rather markedly in bright light, especially when exposed to the strong action of the sun's rays. If the lithopone is practically pure, and does not contain small portions of nickel, cobalt, iron, lead, manganese, copper, thalium, cadmium, or other impurities, the paint does not darken, and is considered absolutely fast to bright sunlight.

High-grade lithopone paints are now extensively used for interior walls and usually give satisfaction as undercoats for enamels. A few days of exposure in bright sunlight on one of two samples coated with white lithopone paint will show whether the mixture is permanent enough to use as an undercoat for enamel. One of the samples should be kept in the dark; and after the other one has been exposed to bright sunlight for several days, both painted surfaces should be compared to discover whether there has been any darkening on account of exposure.

---

[3] See Ch. Coffignier, *Colors and Varnishes,* p. 45.

5. *Two coats of enamel* are recommended for a high-grade *finish.* The first coat, however, may be a mixture of equal parts of properly colored enamel and undercoat paint. This reduces the expense somewhat, and provides a surface that will receive the finishing enamel-coat more readily, and which is more elastic than the final coat of enamel. The most beautiful effect is made by the use of two coats of enamel, the first being very carefully sanded to cut the gloss with No. 4/0 sandpaper after three days or more for drying.

Enamels are more easily applied when rather thin, because such thin mixtures work more easily and do not pull so hard under the brush. Turpentine, or turpentine and benzine in equal parts, may be used as a thinner to a limited extent; but, if thin coats of enamel of half strength are wanted, it is desirable to dilute with a prepared enamel reducer, or to mix one by taking three parts of turpentine and one part of enamel-varnish, such as dammar-varnish or pale copal-varnish. Thinning with too much turpentine dulls a gloss enamel; therefore, instead of using turpentine alone as a diluent, varnish is diluted with turpentine in varnish-reducers, which are to be used where much thinning is necessary, Enamels are generally brushed on surfaces with much care, using a rather large chisel-pointed fitch rubber-set varnish-brush. Such brushes, made of moderately fine and soft bristles, can be used to touch up a surface by rebrushing the coat with a somewhat dry brush, if this is done very soon after the enamel film is applied, and before the varnish in the medium has set to any great extent. Temperatures for enameling are similar to those for varnishing—between 70° and 80° F.

6. The *last coat* of gloss enamel should be rubbed, not sanded. Very soft dull gloss finishes can be secured from gloss enamels by rubbing the surface with pumice-stone and water, or even with pumice-stone and a pale rubbing-oil. Dark rubbing-oil should not be used on a white-enamel surface as it may discolor it. Flat and satin-finish enamels should not be rubbed.

A glossy surface of enamel can be "flatted" to some extent by the application of a wash of turpentine which will "kill" much of the luster.

7. An *optional finishing coat of varnish* may be applied. A rather light coat of good rubbing-varnish is sometimes used over a gloss-enamel finish which has been sanded. The final finish is rubbed with pumice-stone and water, following the methods used for rubbing varnish. It is not desirable to varnish over a white-enamel finish, however, as the color in the varnish is apt to discolor the snowy whiteness of the enamel.

169. A Cheap Enamel Finish.—Specifications for a *cheap, quickly-made enamel finish* are as follows:

1. Prepare the surface of the wood with tools and sandpaper.

2. Size the surface with shellac of one-half strength if the wood or surface be of a porous or very absorptive kind.

3. Apply two coats of properly colored lithophone paint, or some other enamel undercoating material, such as that which is purchased already prepared, or which is similar to the mixture previously described, in paragraph 4, page 204. Puttying and sandpapering should be done between the undercoats. Each application of paint must have at least two days for drying.

4. A coat of equal parts of enamel and undercoating paint should next be brushed on as a foundation for the finishing-film of enamel. It should be of the same color as the final coat. Approximately three days are required for drying; then the surface should be sanded with No. 2/0 to No. 4/0 sandpaper.

5. The final finishing-coat is of enamel, often in full strength, but sometimes thinned slightly in order to make it flow more easily and evenly with a brush.

6. A rubbed finish may be obtained, if gloss enamel is used, by rubbing the surface with water and pumice-stone after the coat has dried

for four or five days. Satin-finish and dull enamels are not rubbed, and require no polishing.

170. Refinishing Old Painted or Enameled Surfaces.—The reenameling of old surfaces which were finished originally with varnish, paint, or enamel often presents rather difficult problems, especially if the old finish be in bad condition. The workman must carefully inspect and scrape the old finish with his putty-knife to determine whether it is firmly adhering or clinging to the surface in blisters, scales, or loose fragments. If the former finish consisted of paint or enamel which has become loosened, then paint and varnish-remover should be used to take off everything down to the original surface. On the other hand, if the former paint and enamel have not cracked or scaled off in spots, and present a firm, hard, smooth, and level surface after thoro sandpapering, then new undercoats of the proper color can be brushed over the old finish and resanded between coats. Before any new paint is applied, all surfaces should be scraped, sanded, and washed to remove any grease. If wax has been applied over an old varnish, it is very important that it be entirely removed with gasoline, benzine, benzol, or turpentine, because other finishes will not adhere to a waxed surface.

In refinishing with enamel, it is often possible to omit the shellacking and priming-coats. If they are found necessary after entirely removing an old finish, they should be applied, and the directions for new finishes followed. The number of undercoats depends upon the covering and coloring-power of the paint which is being applied, and the grade of finish desired. A good refinishing job can often be obtained by the use of two coats of properly colored undercoating paint, followed by another of one-half enamel and one-half undercoating paint, prepared as described previously in this chapter, together with one coat of enamel of the desired color for the final finish.

171. Application of Enamels.—It is necessary that enameling be done in a place having a temperature of 70°

to 80° F. If the temperature is below 70° F., the enamel will not flow freely under the brush, which will seem to stick to the surface or "pull," making it impossible to spread the new coating quickly, evenly, and easily.

Enamel which is too thick spreads with much difficulty, because the brush does not slide freely over the surface but sticks and "pulls," much as it does when the room and material are too cold. The surface is apt to show brush-marks and waves and an uneven surface if a finisher attempts to apply too heavy a coat. Thinning with an enamel-reducer, previously described, is the proper remedy.

A rather thick or heavy coat can be applied in a warm room if the enamel is warmed by placing the container in a pan or pail of hot water which has been removed from the fire. A thick enamel may be made to flow on the surface more easily by slightly thinning the mixture with camphorated turpentine, prepared by dissolving one-half ounce of gum camphor in a quart of turpentine or a mixture of equal parts of turpentine and benzine. Instead of thinning with camphorated turpentine, some finishers prefer to add small quantities of water-white kerosene, glycerine, or even olive-oil or castor-oil. On account of their color the oils just mentioned may be objectionable for use in white enamels. All things considered the most satisfactory method of spreading thick enamel is to apply it when it is warm and in a warm place.

Enamels dry much faster in a warm than in a cold room, and present smoother and more attractive surfaces. If a finishing-room becomes cold at night, a wet film or coating of enamel dries slowly; consequently it absorbs more dust particles which are as harmful to such a finish as to a varnished surface.

Success in enameling often depends upon the following factors: having a warm dust-free room, a clean, suitable brush, and an enamel that has been strained to remove all specks, sediment, and dried, hard particles that are frequently found in cans of prepared enamel. The prepared enamels which are marketed in cans should be thoroly stirred, and then strained thru a screen of very fine mesh, or thru a lintless piece of cloth, such as an old white linen handkerchief or other similar material.

If a finisher forgets to strain a prepared enamel, he will find that he cannot spread the mixture in such a manner that the surface does not show many objectionable specks which always spoil a finish. Sometimes trouble comes because the new enamel coating cannot be made to adhere properly to the undercoats. Such difficulties are liable to be caused by a glossy surface or oily spots on the undercoat. The gloss of an undercoat must be cut off by proper sanding; and all oil, wax, and grease must be removed with gasoline. After the gasoline has evaporated it is advisable to wipe the surface with a clean cloth, or wash it with soap and water, and wipe it dry after proper rinsing. Marks of greasy fingers may also cause trouble unless carefully removed.

172. Covering-Capacities of Enamel and Paint Undercoats.—The covering-capacities of enamels vary somewhat with their fluidity or the relative amount of pigments and other solids contained in the medium, which consists of thinners or solvents and sometimes a small amount of drying-oil. One quart of the prepared enamel, without the use of thinners, when spread by an expert finisher in a warm room, will cover from 100 to 150 square feet of surface with one coat. The undercoat paints under similar conditions have about the same covering-capacity.

REFERENCES—CHAPTER XII

Enamels and Enameling

J. G. Bearn, *The Chemistry of Paints, Pigments, and Varnishes,* "Black Japans," p. 253; "Enamels," pp. 8, 9; "Lithophone Undercoat Paint," pp. 52-6.

Berry Bros., *Varnish-Gums, Varnishes, and Varnishing,* "Dammar-Varnish used in Enamels," p. 21; "Asphaltum in Black Enamels," p. 21.

Bureau of Standards, United States Department of Agriculture, Circular No. 69, *Paint and Varnish,* p. 64.

Ch. Coffignier, *Colors and Varnishes,* "Lithophone Paints" (An Enamel Undercoater), pp. 43-6.

Harry R. Jeffrey, *Wood-Finishing,* p. 98.

A. A. Kelly, *The Expert Wood-Finisher,* "Enameled Furniture," pp. 154-5.

A. A. Kelly, *Expert House-Painter,* pp. 10-18.

A. A. Kelly, *Expert Paint-Mixer,* "White Used in Enamel," p. 31.

Materials for the Household, Bureau of Standards, United States Department of Commerce, Circular No. 70, p. 123.

R. A. McGee and A. G. Brown, *Instruction-Units in Wood-Finishing,* Unit No. 9, pp. 63-6.

R. S. Morrell and A. de Waele, *Rubber, Resins, Paint, and Varnishes,* "Zinc Oxide in Enamels," p. 113; "Lithophone in Indoor Paints and Enamels," p. 119; "Enamels," p. 137; "Manufacture of Enamels," p. 147.

W. K. Schmidt, *Problems of the Finishing-Room,* pp. 235, 237-8.

F. N. Vanderwalker, *Wood-Finishing, Plain and Decorative,* "Enameled Interior Wood Trim," Chapter XIX, pp. 253-9.

F. N. Vanderwalker, *Automobile Painting,* Chapter XIV, pp. 196-9.

CHAPTER XIII

Oil or Oleoresinous Varnishes

HISTORY—PURPOSE—CLASSIFICATION—COMPOSITION

173. Brief History of Varnishes and Varnish-Making.—The old saying which informs us that "There is nothing new under the sun" seems to be true about varnishes. The history of varnish reaches back almost to the very dawn of the history of human beings.

From time immemorial varnish has been used to *beautify* and preserve. The close connection between the two words—varnish and beauty—is shown by the derivation of the word varnish itself. History tells us that in the North African city of Cyrene, which was the capital of a Greek colony, there lived during the middle of the third century B. C. a very beautiful woman, Berenice, the attractive and faithful wife of Ptolemy Euergetes, King of Egypt. Soon after her marriage to the king this golden-haired woman made a vow that she would sacrifice on the altar of the goddess, Venus, her golden or amber-colored hair if the king, her husband, should come back safely from a war in Asia. The story is mixed with mythology which tells us that the shining hair covered with jewels was wafted from the altar to heaven and formed a constellation in the Milky Way which we still know as *Coma Berenices,* or Berenice's Hair.

The Greeks, who were a seafaring race, had imported a beautiful resin which we now call amber, probably from France or Denmark or from the shores of some other distant northern sea. This attractive material was like the color of Berenice's hair, and it was then given the name of Berenice. For many centuries after the time of the famous Queen of Cyrene, the Greeks and Romans prized and valued amber, which was the resin that was used in making varnish, and continued to call it Berenice. The word was also written in Greek in a slightly different form —*Pheronice*—and sometimes pronounced with a sound like our *V* for the *Ph.* In Latin the word was at first written in the form, *Verenice,* and later changed to *Vernix,* which is said to be the root word of the word varnish in the English language.

The inventor of liquid varnish is unknown. Its use, however, reaches far back into antiquity. From time to time samples of very old varnish have been discovered; for example, when some of the tombs of Egypt were opened, mummy-cases, evidently 2500 or more years old, were found, finished with a pale yellow varnish that was scarcely checked by age and the elements.

Altho the coats of varnish on the mummy-cases and other wooden articles have lasted well, the finishing-materials were very poorly applied, indicating that there were no brushes at that period of the world's history. The workmen evidently spread or smeared the liquid varnish over the surface with some tool having a flat surface—possibly a spatula or trowel. It is known that spatulas were used in later centuries for spreading thick varnish, and it is probable that this same method was used for many centuries.

The composition of these old varnishes is absolutely unknown. They are thought to have been compounds of some of the resins then known in North Africa and an oil, probably oil of cedar, which is quite similar to our turpentine. A. H. Sabin, a very careful student of the history of varnish, thinks that the mummy-case varnishes may have been made from some African resin which was then known to the Egyptians, together with linseed-oil.[1] It is known that very ancient peoples had flax, and that they knew how to prepare some of the vegetable oils, particularly olive-oil. It is, therefore, quite possible that the Egyptian varnishes may have been drying-oil varnishes rather than volatile-oil varnishes which were made from an evaporating oil, such as oil of cedar.

---

[1] See A. H. Sabin, *Technology of Paint and Varnish,* p. 8.

Varnishes have evidently been used thruout all the ages —from practically prehistoric times in Egypt down to the present day. Mention of varnish is made in the manuscripts of many of the world's great writers. Pliny, who lived during the first century, A. D., in writing about Apelles (1.XXXV, C. 18), the court painter of Alexander the Great during the fourth century B. C., wrote: " . . . that he spread the varnish over his completed work so thin that it brought out the brilliancy of the colors by reflection and protected it from dust and dirt."

The most important and valuable of the treatises on varnish coming from the middle ages is found in the writings of Theophilus Presbyter who was a Swiss or German monk. This man was probably also the same person as Tutilo, or Tuotilo, who lived in the monastery of St. Gall. This monk tells how to make varnish out of fornis or glassa (amber) and linseed-oil by use of a heating and mixing process.[2] His formula called for one part of powdered amber with two parts by weight of linseed-oil—the two substances to be properly heated together.

Varnish like the above was especially used to cover paintings. It was not spread with a brush, but was smeared over the surface of paintings with the fingers, and over boards, probably, with a spatula.

The various formulas for varnish-making used during the middle ages contained linseed-oil and a resin, such as amber or sandarac, which were mixed while hot. Some of the formulas after about 1520 suggested dilution of the varnish with naphtha, spirits of wine, or linseed oil.[3] Burnt rock alum was often recommended for an ingredient to be mixed with the boiling linseed-oil and resin.

While some slight changes were made from century to century, it seems probable that there was little improvement in varnish-making for about 800 years—from the time of Theophilus in the tenth or eleventh century until near the end of the eighteenth century. It also seems quite probable that the oil and amber formula for varnish-making was handed down to Theophilus from the mummy-case varnishers of Egypt who knew how to make similar varnishes at least as early as 500 B. C.

---

[2] See A. H. Sabin, *Technology of Paint and Varnish,* from a translation from the Latin, pp. 12-14.

[3] See A. H. Sabin, *Technology of Paint and Varnish,* "Formulæ from the Marcian MS., 1520," p. 17.

174. Purpose of Varnish.—It is very evident that man must have had some very definite purpose in mind which prompted him to use varnish on precious articles in the past and to continue to use it thruout all ages since the dawn of civilization. The reasons for the use of varnish as a finishing material are many, some of which are obvious to the casual observer, while others are discoverable only thru the use of the material itself. The two chief purposes that the wood-finisher has in mind for using varnish are the preservation of the material and the unfolding or development of beauty.

Preservation is secured in various ways—such as thru the addition of hardness to the surface; thru protection from wear and abrasion; thru the exclusion of moisture to a large extent, thereby preventing swelling, warping, and raising of the grain; thru the extension of the life of the article because of the shutting out of rot fungi and moisture which are the agencies of decay; and thru protection of the surface itself in such a manner that cleaning can be done with water without damage to the material which is covered by the film of varnish.

Beauty is often made more manifest, and is amplified or revealed, by the use of varnish in a number of ways—such as thru making more permanent the freshness, the newness, and the attractiveness of the grain if the article be of wood; thru prevention of the fading of alluring natural colors or of stains which are somewhat fugitive; thru warding off or delaying the dulling or graying changes from weathering, or the chemical action of gases or liquids; thru the leveling effect of filling up pores or small openings; and thru putting a polish on the surface itself, or thru the production of a pleasing gloss or luster that adds attractiveness to the general appearance of the article.

175. Classification of Varnishes.—The method of drying divides all varnishes into two very distinct classes: (1) *spirit-varnishes,* which dry thru evaporation and contain various volatile solvents, such as alcohol and turpentine; (2) *oil-varnishes,* which contain drying-oils that dry or harden slowly thru oxidation, the most important drying-oils being linseed-oil and tung-oil or China wood-oil. The spirit-varnishes can be divided into two classes, one of which contains an alcoholic solvent, and the other a rapidly-drying volatile oil such as turpentine.[4] Oil-varnishes, which are often called oleoresinous or fixed-oil varnishes, contain a volatile oil, which evaporates quickly, in addition to the fixed or oxidizing oil which remains in the film and gradually takes on more oxygen.

The resins selected for use in oil-varnishes are generally chosen from the hard or semi-hard group, with the exception of rosin (colophony), and these resins are not easily soluble cold; consequently in the manufacture of varnish, all hard gums are heated until they are melted, and, in this condition, they are soluble in hot drying-oils, forming a mixture that can be thinned with volatile oils before becoming cold.

The chief difference between spirit-varnishes and oil-varnishes is in their methods of drying, spirit-varnishes drying by evaporation alone, and oil-varnishes drying partly by evaporation and partly by oxidation, and possibly other slow chemical changes.

Two other types of varnish which are somewhat different from spirit-varnishes and oil-varnishes are sometimes given in classifying varnishes; these are known as japans and enamels.

Japan-varnishes, also called painters' japan-*driers,* are sometimes considered as a third type of varnish.[5] Japan-driers are intended for mixing with drying-oils, varnishes, and paints and for use as grinding liquids.

---

[4] See Section 139, "Spirit-Varnishes Defined," p. 164.

The purpose of the japan-drier is not the same as that of varnish. Varnishes are ordinarily used as coatings or films, but japans are not meant for such purposes. Liquid japan-drier is used simply as an ingredient in other mixtures in order to increase the rapidity of the oxidation of the drying-oils. Japans are manufactured much like oil-varnishes, and contain a gum, usually rosin because of its cheapness, a drying-oil such as linseed-oil, or preferably tung-oil, or both, and solvents of volatile oils such as turpentine and heavy naphtha 48°, benzine, and kerosene 46°. An excess of drier, or at least more than is used in varnishes ordinarily, is added to the mixture. The driers are the same as those contained in oil-varnishes; namely, litharge, red lead, manganese dioxide, manganese borate, manganese resinate, and lead and cobalt acetate. The oils, gums, and driers are given heat treatments somewhat similar to those used in manufacturing oil-varnishes.

The black baking japans are not driers, but are similar to enamels. They are much like varnishes but usually contain little or no varnish gum. Sometimes rosin is used; in which case it is substituted in part for some of the black gums, such as "parolite," a petroleum asphalt (manufactured by the Standard Oil Company), or gilsonite, a very black, brittle gum that lends a high luster to baking japans. The oil used in these black baking varnishes is principally linseed-oil, altho cheaper oils such as soya bean and menhaden oil are sometimes used in the cheap grades. The thinners used are kerosene, benzine, and solvent naphtha.

The term *drier,* when used with discrimination, refers to cookings of China-wood or linseed-oil and drying salts, which are heated together at temperatures of about 500° F. (260 C.).[6] True driers do not contain gums, such as rosin, while japans are made with rosin or some other gum as a base.

---

[5] See also Section 189, "Driers and Their Functions in Oils, Varnishes, and Japans," p. 240.

[6] See Section 189, "Driers and Their Functions in Oils, Varnishes, and Japans," p. 240.

The term *enamel* is applied to various mixtures which are used in several industries that have little connection with each other. Wood-finishers' enamels are of many kinds with varying compositions. They are very often pigmented varnishes or varnish-paints, but sometimes they are similar to air-drying japans usually with coloring-matter in addition. The wood-finisher thinks of enamels as being in the border-land between paints and varnishes.[7]

176. Composition of Oil-Varnishes.—The essential ingredients in the composition of an oil-varnish can be divided into four classes as follows:

(1) The *resin,* a fossil resin preferably, that hardens thereby giving the film its luster, brilliancy, and hardness, and increasing its durability. The function of the resin is to give "body" or thickness to the film; it also adds beauty and utility.

(2) The *drying or oxidizing oils* are solvents for resins in a melted condition, and remain in the film, giving it elasticity and acting as a binder for the gums thus making the varnish more durable. Such oils affect the luster of films containing them to some extent and add waterproof qualities. The drying-oils are often called the vehicle of the varnish.

(3) The *solvent* is a volatile oil such as turpentine, varnolene, or some other similar mineral oil that can be used to make the varnish more fluid and thin enough so that it can be spread with a brush.

(4) *Metallic driers,* such as dioxide of manganese, red lead, or some of the other salts of lead which will increase the rapidity of the oxidation of the drying oils.

177. Secrets of Varnish-Making.—During many centuries the details of varnish-making were considered to be trade secrets, but with the rapid progress of science the old secrets have largely disappeared as such. Instead of being a process of alchemy, varnish-making is now directed by a scientifically trained chemist whose knowledge is theoretical as well as empirical.

---

[7] See Chapter XII, "Enamels and Enameling," p. 192.

The manufacture of varnish has become a very highly technical process that requires considerable equipment, skill, and technical knowledge. The resins used in oil-varnishes melt at various temperatures usually between 105° C. (221° F.) the melting-point of rosin, up to 260° C. (500° F.), which is the temperature for melting hard congo gum. The heat treatments which are given to the resins and oils in the kettles change the qualities of varnishes to a great extent.

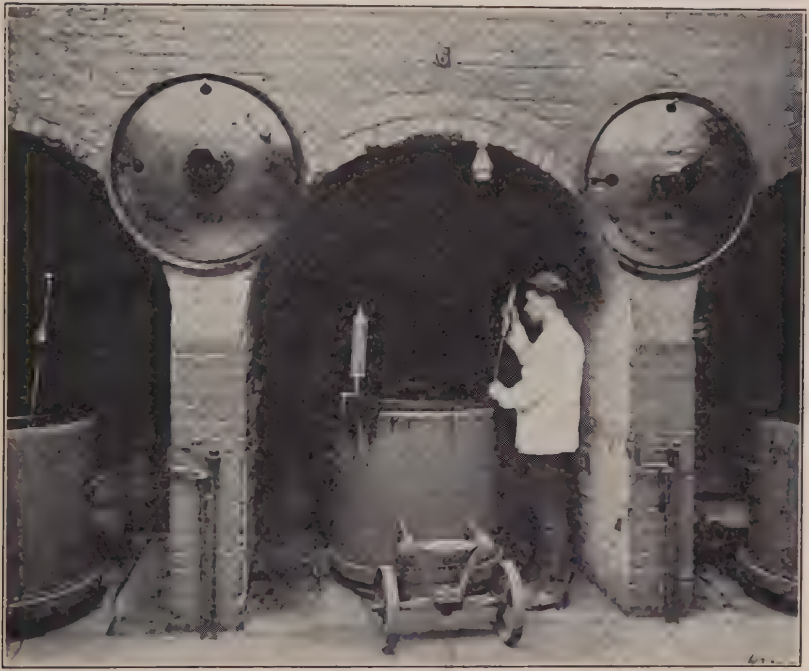


FIG. 18.—VARNISH KETTLE AND THERMOMETER IN A CHIMNEY.

Varnish kettles are placed on wheels or trucks in order that they may be removed from the fire quickly. See the covers to the kettles hanging on the walls. Courtesy of the Sherwin-Williams Co.

A copper kettle, cylindrical in shape, three feet in diameter and about the same height, is used for melting varnish, Fig. 18. Manufacturers usually melt 125 pounds of gum at a time in a kettle of copper which is located on a truck of metal. The varnish-kettle containing its batch of resin is rolled over a glowing coke fire which slowly melts the gum. The cover of the kettle has a pipe which allows the irritating and inflammable vapors to escape thru a large chimney with a strong draft, located just above the kettle which is pushed into a niche or opening like a great fireplace at the base of the chimney itself.

The resin is kept in a molten condition for several minutes, and is stirred with a long rod by an operator who watches the cooking process. The melted resin foams at the top and gradually loses weight, varying from 10 per cent to 25 per cent in amount. The amount of loss varies with different resins. Temperatures up to 350° C. (642° F.) are often used for the hard resins, and slightly lower temperatures of 290° C. (554° F.) are used for some of the softer gums.

Most of the resins which are the best ingredients for oil-varnishes are not soluble in the oils or solvents that are incorporated into varnishes until they have had a proper heat treatment and are reduced in weight from 15 to 25 per cent by evaporation. The amount of loss of weight that is necessary is reported by Morrell and de Waele to be in a direct proportion to the hardness of the gum, and to age or degree of fossilization.[8] The drying-oils are generally poured into the molten resin while it is still hot enough to be fluid and after the kettle has been removed from the fire. The oil is also heated and mixed with driers and is usually hot when mixed slowly into the molten resin.

The oil and resin do not easily mix; consequently, the mixture must be re-heated and stirred, and kept at a temperature around 287.7° C. (550° F.) until it is properly cooked, which requires from an hour or two to six or eight hours. Undercooked varnishes will not receive the proper amount of turpentine and other thinners nor spread in a thick film which oxidizes or drys slowly. Overcooked varnishes take up too much turpentine, are too thin, and dry too quickly. Overcooking makes the varnish darker in color and less durable, because films made from a varnish with much turpentine in its composition are thin. Undercooked varnishes are apt to have the resins poorly combined with the drying-oils, and are difficult to thin to a proper brushing consistency.

---

[8] See R. S. Morrell and A. de Waele, *Rubber, Resins, Paints, and Varnishes*, p. 184.

During the heat treatments or cooking of varnishes, the resins are melted and kept hot for a long period of time, during which great changes take place. It is known that at the high heat used by the varnish-maker the gums are decomposed, and vapors are driven off which contain some of the original ingredients of the resins themselves. The weight is often reduced as much as one-fifth, leaving a residue which is materially changed chemically and physically. The vegetable drying-oils are also changed by high heat, being oxidized in part, and probably polymerized or so modified that the molecular weights of some of the component parts of the oils are different. It is evident that heat treatments at different temperatures, or even variations from short and prolonged cooking at the same temperatures, produce varnish materials that vary in composition and characteristics, and that these variations cause just as great differences in films of the varnishes that are made from them. These changes in the raw materials, such as gums and oils, are so great during heat treatments that a chemical analysis of a varnish after it is made does not reveal much, and the raw materials themselves cannot usually be identified.

178. Resins Used in Oil-Varnishes.—Nature has produced a large number of resins that can be used in oil-varnishes. To these valuable gums, some of which have become fossilized thru contact with the ground during long ages, man has added others which he has produced synthetically. Some of the hardest and best of the fossil resins, such as amber, Benguela copal, and the Zanzibar animi, have practically disappeared from varnish-making because it is almost impossible to secure sufficient quantities and the cost is great.

The word *copal* is a generic or family term which includes all of the fossil resins, such as the Zanzibar animi, the Congo copals, kauri gums, hard Manila gum, pontianak, and amber. The Sierra Leone gum is a valuable African resin that is often called a copal altho it is not a fossil resin, but a recent formation collected directly from a tree.

Various grades of each of the copal resins are often found on the market, classified according to color, the palest being the highest grade. Freedom from foreign matter is considered. The size classification also changes the price. The coarsest and best grade is called ''bold''; the next smaller is designated ''nubs''; then ''chips''; then ''seeds''; and finally ''dust.''

The quality, color, and durability of any varnish depend in large measure upon the gum used in its manufacture. The resin itself is, however, not now considered of as great importance as formerly, because it has been found that certain desirable qualities can be added to the varnish thru the use of China wood-oil, and when this oil is incorporated into a varnish a cheaper, lower-grade resin can be used and still make a good varnish. A brief study of the resins or gums now used in varnish making may be of interest.

179. Congo Gum.—The Belgian Congo region furnishes a fine copal resin which is very hard and light in color. The French Congo yields a resin that is softer but still whiter than that of the Belgian district. The Congo gums are all classed as hard copals, having a high melting-point, 260° C. (500° F.).[9] Congo gums cannot be dissolved cold, and require melting and reducing in weight by heat treatment until about 25 per cent of the original resin is driven off in gases, then the residues are soluble in hot drying-oils. In making varnish, Congo gums are cooked with drying-oils at temperatures varying from 300° C. (572° F.) to 375° C. (667° F.).

---

[9] See Winfield G. Scott, *Formulas and Processes for Manufacturing Paints, Oils, and Varnishes*, p. 206.

Congo gum is available in large quantities in various grades and at reasonable prices. It is used in large quantities for high-grade varnishes, especially for very pale grades for interior use or baking varnishes.

180. Kauri Resin.—The kauri copal which is used in varnish-making is a fossil resin found in New Zealand. The resin comes from the kauri pine, a slow growing tree that lives to be about 500 years old and attains great size. The tree in appearance is not like our pine trees because it has leaves instead of needles. The leaves are from 1½″ to 2½″ long, from ½″ to ¾″ wide, and are of a thick, leathery, shining, greenish-brown color. The kauri pine tree bears cones, however, which show that the tree is a *Gynnosperm* and is related to the pines.

There are living kauri pine trees growing in the gum region at present which exude a soft resin. The fresh gum is said to be of no value to the varnish-maker.

The fossil kauri resin is dug from the ground at depths usually varying from 3 to 10 feet. No one knows how the fossil gum came to be buried several feet in the ground on a level where a former forest of kauri pine trees once stood. It is known that gum exudes from kauri trees around wounds from broken limbs or other injuries. Fire probably destroyed the original forests leaving gum from the trees which winds and decaying vegetation finally covered over with earth to a new level.

The fossil kauri resin is dug out of the ground by thousands of gum diggers who use sharp metal spears to prod or drive into the ground in search for something hard. Digging is started whenever any obstruction, which the spear runs against, is thought to be a chunk of resin. Excavations are sometimes made with machinery by companies that hunt for gum on a large scale. Water is also used in connection with machine digging in order to wash away loose dirt and to clean the chunks of gum.

Kauri resin is found on the market in several grades which are called pale kauri, brown kauri, and bush kauri. The pale kauri is the best grade and is a true fossil resin, while the bush kauri is of more recent origin. The best of the pale gums is known as Dial XXXX, with slightly cheaper grades called Rescraped XXX, XX, and X. Cheaper than the above grades, which are very expensive, are No. 1 which is often used in varnishes, and No. 2. The very cheapest grades of kauri resin are called "chips," then "seeds," then "dust," the latter being the poorest of all. The very best grades of white dial kauri gum cost about $1.25 a pound on the New York market, while the No. 1 grade is sold at 50 cents. The brown kauri in similar grades costs only about two-thirds as much. Kauri gums at present cost about twice as much as similar grades of Congo resins.

Kauri gum is at present probably the most commonly used fossil gum for varnish manufacture. It makes a very durable high-grade varnish, especially for rubbing and polishing.

The melting temperature of kauri gum is slightly less than that of the Congo resins, the fusing point of the brown grade being given as 265° C. (509° F.). In the manufacture of varnish, high temperatures of about 350° C. (642° F.) are ordinarily used in order to reduce the weight of the resin and make the melted gum more liquid.

181. Pontianak.—This is a very hard gum that comes from a city of the same name in Borneo. It is often spelled "pontianac" in trade use. In qualities it somewhat resembles the semihard manila resins. It is a rather cheap gum often selling in large chunks of the so-called "Bold" grade in the "Clean-Scraped" quality at from 24 to 27 cents a pound, while the wholesale price of "Chips" is about 13½ to 15 cents.

The melting-point of pontianak gum is 226.6° C. (440°

F.). Varnishes made from pontianak gum are usually heated to a temperature of from 325° C. (617° F.) to 350° C. (642° F.) during the melting and cooking process.

Pontianak resin is especially recommended for use in coach- and spar-varnishes. It is said that coach-varnishes properly made from the pale grades of this hard gum, when not mixed with rosin, will not turn white in water. Very superior polishing-varnishes are manufactured from pontianak gum which is often mixed with about 20 per cent of rosin. In color pontianak resins vary from almost transparent or milky white effects to yellow and even reddish-brown.

182. Manila Gums.—Two distinct kinds of resins are sold under this name, coming chiefly from Manila, tho shipments of similar gum are also said to come from Borneo, Macassar, and Singapore.

The soft manila gum is completely soluble in alcohol and is often used in spirit-varnishes. This is a recent resin which is collected from growing trees either from incisions in the bark or thru removal of strips making wounds to which the tree responds by throwing out a gum which is collected by the natives. The color of the soft gum varies from white to brown or red. Its melting-point is low, about 120° C. (248° F.).

The hard manila resin is a true copal or fossil gum that is dug out of the ground. It varies from a dull white or pale yellow to a deep brown in color, and breaks with a bright fracture. In hardness the hard manila resin is slightly softer than congo gum and somewhat harder than kauri or the gum from Sierra Leone. The hard manila resin is soluble in amyl alcohol and amyl acetate which solvents are sometimes used in nitrocellulose lacquers; but it is 73 per cent insoluble in turpentine, 64 per cent insoluble in benzine, and 56 per cent insoluble in alcohol.

The best grades of manila gum are rather cheap in comparison with other hard resins, selling at about 24 cents a pound wholesale for the ‘‘Bold’’ XXXXX grade which is the best, and 13 cents for the ‘‘Seed’’ grade.

In the manufacture of varnishes, hard manila gum is usually mixed with rosin in various amounts and does not seem to be used alone very often if at all. Hard manila resin is recommended for quick drying, mixing, pale elastic, rubbing and polishing, and some other varnishes. Some varnishes are made with a rather low heat treatment of 250° C. (482° F.) to 270 C°. (518° F.) when using hard manila gum, while others use 350° C. (642° F.).

The melting-point of hard manila gum is probably about 242.2° C. (468° F.). The pale varnishes are made at low heats and darker varnishes at high heats. In general, hard manila gum is used in rather cheap and medium-priced varnishes intended for inside application rather than for outdoor exposure to the weather.

183. Rosin and Resinates.—The cheapest of all the resins that can be used in oil varnishes is called rosin. It is made from the crude gum or oleoresin which is obtained by scarifying or ‘‘chipping’’ the sap-wood of various species of pine trees, particularly the Southern longleaf yellow pine (*Pinus palustris*) which grows in the southern portion of the United States of America. Rosin probably might be called a by-product of the manufacture of gum turpentine because it is a less volatile residue which is separated from the oil by distillation and remains in the still while the turpentine and water, on account of their lower vaporization point, pass out and are collected thru condensation.

The composition of French rosin which is manufactured from crude gum from the maritime or cluster pine (*Pinus maritima* or *pinaster*), a tree of the coast districts of southwestern France, is somewhat different from that made from any of the pines which produce turpentine in the United States. Rosin has been studied very carefully by chemists during the past 25 years; but it is such a complex substance, and varies so much in composition, when made from gum taken from different species of trees, that it is still a great problem for research. American rosin is said to contain a large proportion of free abietic acid, which has certain isomers called pinic acid and sylvic acid. The French rosins are reported to contain, not abietic acid, but another similar acid which chemists call pimaric acid.[10] While the different rosins are not exactly alike chemically, they are said to contain resenes which are thought to be produced from terpenes by oxidation and other chemical reactions, such as polymerization. (Polymerization means a change in molecular weights while the various elements retain the same percentage relatively in the molecule.)

Rosin, or colophony as it is often called, is very brittle, breaking with a glassy fracture. It is highly acid in reaction unless treated with heat and pulverized quick lime (CaO), or 5 to 6 per cent of slaked lime ($Ca(OH)_2$) and cooked at 250° C. (482° F.) to 270° C. (518° F.) until there is a loss of weight of about 13 per cent. This mixture of treated rosin is much harder, and is called a resinate of lime or calcium resinate ($Ca(C_{20}H_{29}O_2)_2$).[11] Other resinates are made from rosin by heat treatment with litharge, making a lead resinate ($Pb(C_{20}H_{29}O_2)_2$); with manganese dioxide, producing a manganese resinate ($Mn(C_{20}H_{29}O_2)_2$); with cobalt oxide, which forms a cobalt resinate ($Co(C_{20}H_{29}O_2)_2$); or with zinc oxide, which creates a zinc resinate ($Zn(C_{20}H_{29}O_2)_2$). The chief function of changing rosin to a resinate thru heat and lime or thru the addition of metallic oxides is to reduce the acidity of the rosin and to harden the mixture in order to make it wear more satisfactorily in a varnish film.

It should also be stated that lead and manganese resinates are well-known driers of great power, and that zinc resinate is a good hardener of oils as well as of rosin tho it possesses no useful drying properties. Treatment with too much lime or oxides makes the resinate too hard and insoluble. Prolonged heat treatments decrease the acidity and increase the hardness of resinates. Ordinary rosin melts usually above 130° C. (266° F.), but the hardening effect during the heat treatments and the acid change in the formation of the resinate in some way combine to raise the fusing-point of the new material about 50° C.

---

[10] See J. Gauld Bearn, *The Chemistry of Paints, Pigments, and Varnishes*, p. 161.

[11] See E. Perry, *Varnishes, Driers, and Drying-Oils*, "Resinates," pp. 15, 16.

Specially prepared rosins for use in varnishes are now obtainable or can be made by many different methods. Rosin gum in preparation is very often melted at a temperature varying from 205° C. (401° F.) to 260° C. (500° F.), then slaked lime is added. Many of the best resonates are given other treatments, sometimes with lead acetate and concentrated lye in a solution of water which is poured into the melted rosin at about 205° C. (401° F.). The rosin mixture is then reheated to about 260° C. (500° F.) before the slaked lime is added. After this another heating to about 300° C. (572° F.) is given for a very short time.

Rosin has generally been considered the very poorest possible gum for use in a varnish, because films made with it are brittle, do not wear very well, and turn white in contact with water. The good fossil resins are the best material obtainable, but they are expensive and sometimes difficult to obtain. During the search for a cheaper resin it was discovered that rosin properly heat-treated and changed to a resinate, in combination with tung-oil which has superior qualities, can be used at least in part as a substitute for fossil gums and still produce very useful varnishes.

Rosin is used extensively in cheap varnishes, and in a small part at least in high-grade varnishes. It is said that the acid of rosin is active in combining with small particles of manganese or lead from the driers thus making a clear, homogeneous fluid containing few specks. In this respect rosin is valuable in small quantities even in good grades of varnish manufactured from fossil gums. Rosin varnishes flow very evenly and help other varnishes to make more level and attractive surfaces. Large quantities of rosin in varnishes are, however, always used because the gum is cheaper and not on account of its good qualities. Rosin varnishes have a good appearance when new, but they are short-lived. They soften easily in heat because rosin itself is easily melted and becomes tacky at low temperatures—even in the hot sun or in contact with clothing in hot weather. Rosin is often used in very small quantities in melting high-grade fossil resins because it causes these hard gums to melt more easily and become more fluid.

Rosin varnishes often produce a brilliant surface soon after they are applied, but they seem slowly to break down chemically and lose their luster. After a time they are apt to crack slightly thru a loss of elasticity, especially if the varnish happens to be a short-oil varnish. The size of the cracks gradually increases with time, giving the crackled effect of alligator leather or of a crackle lacquer finish. In the case of the crackle varnish finish, the small pieces soon lose their adhesion to the surfaces and chip off, making an entire refinishing job necessary after the old varnish has been entirely removed.

184. Ester Gum.—A new and valuable resin has recently been produced synthetically by combining common rosin with glycerine thru heat treatments. Rosin generally has an acid number of about 165 according to the chemists. It has been discovered that the rosin acid or acids can be combined in part at least with glycerl, the basic radical of glycerine, and a somewhat different material is produced, called an ester, which is something like an organic salt. An ester is known as an alkyl salt of an acid; in other words, it is the product of the reaction of some alcohol with an acid. In the rosin esters the reaction comes from an acid, probably abietic acid ($HC_{20}H_{29}O_2$), with glycerine, which is called a glycyl alcohol or glycerl. The reaction takes place, however, at high temperatures after the rosin has melted. This new C.P. rosin or ester gum, which is thus formed, has a much less acid reaction than the original rosin.[12] The acid number of ester gums varies from 6 to 50.

---

[12] See E. Perry, *Varnishes, Driers, and Drying-Oils*, C. P. "Rosin," pp. 22, 23.

Ester gum is often manufactured by using 100 pounds of rosin and about 1¼ gallons of glycerine. The cooking should last from 2½ to 4 hours, at a temperature of about 275° C. (527° F.). The shorter heat treatment reduces the acid number of ester gum to about 45 or 50, while the longer period changes it to about 11 to 16, tho with more glycerine it can be lowered to about 6. Ester gums having low acid numbers must not be heated above 282° C. (about 540° F.), or they will jelly with wood-oil if used with it afterwards. Ester gums with higher acid numbers up to about 50 will admit of heat up to 296.1° C. (565° F.).

The melting-point of low-acid ester gums, having an acid number of about 11 or slightly lower, is 160° C. (320° F.), while gums having higher acid numbers of about 16 melt a few degrees lower—157.2° C. (315° F.).

Ester-gum is usually nearly neutral in its reaction; and, when combined properly with tung-oil, it produces a far better varnish than can be made from hardened rosins.

Ester gums are used in varnishes for outside use very extensively because such varnishes weather very well, being much superior to hardened rosin preparations. For waterproof varnishes, ester gums having very low acid numbers, such as 6 to 16, are required; and tung-oil is used almost always, even in the cheapest of such spar-varnishes. Many spar-varnishes made from ester gum will stand submersion in water for long periods of time—several weeks—without turning white, and are said to be absolutely water-proof. Such varnishes should be cooked at temperatures of from 275° C. (527° F.) to 295° C. (563° F.) in order to be properly water-proof. Ester-gum varnishes are much superior to varnishes made from high-limed rosin, because the latter are brittle and hard and are not water-proof.

Ester-gum varnishes when properly made produce a very good luster, tho they may "flat" if prepared at too low cooking temperatures. The low-acid number of ester gums helps in giving varnishes made from them a very neutral reaction which causes them to be excellent for use with pigments of lead and zinc. Ester gums are often found in mixing varnishes for various uses, tho cheaper rosin varnishes are also employed for this purpose.

The appearance of ester-gum varnishes is attractive after they are spread because they flow evenly and easily under a brush and make very level surfaces.

DRYING-OILS IN VARNISHES

Linseed-oil was the only important drying-oil extensively used in varnishes until very recently. Within a few years another drying-oil, which has been well known in China for ages, has found an important place in varnish manufacturing. Each of these oils is at present recognized as having important functions in varnishes. Each has certain characteristics that are valuable tho differing from each other, and it is very common for both to be used in the same varnish. The Chinese oil is called tung-oil or China-wood oil. It is more expensive than linseed-oil; therefore it is not considered an adulterant.

Drying-oils are oils that change chemically, decomposing largely thru oxidation when exposed to the air in thin films which gradually harden. The process of taking on oxygen, or oxidation, is rather slow, the rapidity varying with the different drying-oils. The best known of the drying-oils are perilla, soya bean (or soy-bean), linseed-oil, and tung-oil. Soy-bean oil does not dry rapidly owing to its low iodine value (130) and is not ordinarily used in varnishes.

Perilla oil is an excellent drying-oil, having the highest iodine value (205) of the known vegetable oils. It comes from a nut obtained in the East Indies, Japan, and China; and is expensive, as it is available only in small quantities. Perilla oil produces a quick-drying very hard film, but it has some characteristics that cause it to be ranked lower than linseed-oil for general use. Linseed-oil is the most important drying-oil for use in paints and varnishes. China-wood oil or tung-oil when properly heat treated is often used in spar-varnish and other varnishes on account of its many good qualities. Its expense limits its use to some extent, however.

185. Linseed-Oil.—For several hundred years the drying-oil which constituted the important vehicle used with resins in making oil-varnishes has been linseed-oil. In fact, only minor changes and improvements in varnish-making were made during several centuries, until good fossil resins became scarce, turpentine greatly increased in price, and the good qualities of China-wood oil for varnish manufacturing were recognized.

The proper form of linseed-oil for use in manufacturing varnish is not raw linseed-oil. Untreated raw linseed-oil when heated with varnish-gums to a temperature much above 176.6° C. (350° F.) is apt to "break," or become cloudy with a mucilaginous substance; consequently, treated oils are always selected for heating with resins in making varnishes.

Prepared or treated oils for varnish-making are heated to various temperatures, and generally have driers added. There are many methods of treating oils with heat and driers, the method selected in any case depending upon the purpose for which the oil is to be used.[13] The very palest oils are best treated in an aluminum kettle, because a copper kettle may color the heated mixture to a greenish tinge, and an iron kettle may darken the oil or impart a brownish hue to it. The best stirring-rods for pale oils are made of brass or aluminum.

Sometimes a good linseed-oil is bleached and given better drying qualities thru heat treatment at about 287.7° C. (550° F.) for two hours. There is about two per cent loss in volume by such a treatment. Varnish-oils are, however, usually given still more rapid-drying qualities by the addition of various driers, such as manganese dioxide, manganese borate, calcined magnesia, litharge, red lead, lead acetate, and probably other metallic driers.

---

[13] See Winfield G. Scott, *Formulas and Processes for Manufacturing Paints, Oils, and Varnishes*, pp. 60-95.

There is no standard temperature for the heating of linseed-oils, nor is there a specified standard length of time for the treatment. A few illustrations will give a general idea of the procedure. A pale varnish-oil with a manganese drier is sometimes made by heating V.M. linseed-oil to 315.5° C. (600° F.) for about half an hour, then allowing it to cool and settle. The oil is finally reheated with a drier, such as manganese dioxide (MnO_2). About one pound of the nut-size manganese dioxide should be used to each two gallons of oil, tho more may be added if a stronger drier is desired. The heat treatment for the above conditions should last for about eight to ten hours at a temperature of 160° C. (320° F.).

A darker oil of powerful drying properties may be made by heating V.M. linseed-oil to 115.5° C. (240° F.), then slowly adding a mixture of equal parts of litharge (PbO) and red lead (Pb_3O_4), gradually raising the heat to about 215° C. (419° F.), or even 30° or 40° F. higher, if it is necessary in dissolving the driers. The driers may be used in the proportion of 16 pounds each of litharge and red lead to 100 gallons of linseed-oil. The above proportions represent about four per cent of driers in the total weight. Linseed-oil will receive considerably more drying-salts than the amount mentioned before becoming saturated.

Prepared linseed-oils for varnish-making are somewhat similar in a general way to some of the boiled oils that are sold on the market. The manufacturer of varnishes would not consider any of the so-called boiled oils as exactly suitable or properly prepared for incorporating into varnishes, and usually treats his own oils with reference to some definite use, as for a particular formula. There are several methods of refining the raw oil to start with, and the various metallic driers which differ in their activity and reactions add somewhat different characteristics to the oil. Linseed-oil also seems to be changed somewhat chemically, and probably physically, thru heat treatments, especially at or above 260° C. (500° F.).[14] Some of the boiled oils in common use have had proper driers added, but they have not received the necessary heat treatments for use in varnishes.

Linseed-oil weighs about 7¾ pounds to the gallon at a temperature of 15.5° C. (60° F.). Its viscosity is about 4.00 or slightly less when compared with water, and its specific gravity varies from .931 to .933.

186. Tung-Oil or China-Wood Oil.—Although tung-oil has been known for many years in the Orient, it has only recently been discovered by Europeans and Americans as a very valuable oil for the varnish-maker.

Tung-oil differs from linseed-oil in several characteristics. It cannot be used successfully in its raw state, and requires preparation with driers and heat treatment varying somewhat from that given to linseed-oil. If tung-oil is gradually heated to about 204.4° C. (400° F.), the oil changes into an insoluble jelly; therefore, it must be heated with care to avoid this condition.[15] To prevent the jellying or polymerization of tung-oil, small amounts of linseed-oil or rosin must be heated with it. It is often given heat treatment with about an equal amount of linseed-oil. The same metallic driers that are selected for preparing linseed-oil for use in varnishes are also incorporated into tung-oil.

One method of preparing a quick-drying oil is to use two parts of tung-oil to one of linseed-oil. The linseed-oil should be heated first to about 260° C. (500° F.) with a drier such as manganese borate (MnB_2O_4), using about one pound of the drier to each eight gallons of linseed-oil, and stirring before heating the oil. The tung-oil is then added slowly to the hot linseed-oil. The combined oils are heated to 270° C. (518° F.), and then more drier is added, a little at a time, to the extent of one pound of litharge (PbO) to each two gallons of tung-oil. The litharge should have about three per cent of slaked lime mixed with it in order to make the oil less acid. An oil of this composition contains a maximum of driers and dries very rapidly. Most prepared tung-oils are somewhat similar to the above but usually contain less of the metallic driers.

---

[14] See R. S. Morrell and A. de Waele, *Rubber, Resins, Paints, and Varnishes*, p. 65.

[15] See Alvah Horton Sabin, *Technology of Paint and Varnish* (3rd Edition, 1927), p. 105.

Chinese-wood oil (tung-oil) varies in color from a pale yellow in its best grades to a dark brown color in oils of poor quality. It seems to have rather remarkable drying properties, and in this respect is superior to linseed-oil, altho its iodine number is slightly lower, being about 163 while that of linseed-oil varies from about 178 to 185 for the North American oil.

Varnish-makers who are using rosin in large quantities as an important resin in their formulas claim that tung-oil gives a rosin varnish certain valuable properties that can be obtained in no other way. The makers of rosin-varnish are said to use about nine-tenths of all of the tung-oil that is used in the United States. Ester-gum varnishes also seem to require tung-oil as an important ingredient. China-wood oil is now used as the only drying-oil in many varnish formulas. It seems to give varnishes water-proofing qualities; and, for that reason, it is found in many spar-varnishes. Some rosin and ester-gum varnishes which contain tung-oil as the only drying-oil are claimed to be waterproof if properly prepared.[16] Many other similar varnishes contain a small amount of linseed-oil with tung-oil as the chief drying-oil.

Tung-oil not only dries faster than linseed-oil, but films made from it become much harder. This added hardness is just what rosin and ester-gum varnishes lack to make them more useful and satisfactory. While it is true that varnishes made from cheap gums and tung-oil show up exceptionally well when new, tests show that they are not as durable when exposed to the weather as varnishes which contain fossil resins.[17]

Tung-oil weighs slightly more than linseed-oil, having a weight of 7.84 pounds per gallon at ordinary room temperatures. The specific gravity of China-wood or tung-oil is about .941, which is a little higher than that of linseed-oil, .931 to .933. The viscosity of tung-oil is very high, 20.5, while that of linseed-oil is only about 4.00, compared with that of water.

---

[16] See Winfield G. Scott, *Formulas and Processes for Manufacturing Paints, Oils, and Varnishes;* No. 1734, p. 136; No. 1739, p. 140; and No. 1795, p. 153.

[17] See Alvah Horton Sabin, *Technology of Paint and Varnish* (3rd edition, 1927), p. 110.

VARNISH-THINNERS OR VOLATILE-OIL SOLVENTS

Varnishes would be too thick to spread properly with a brush if they contained only resins and drying-oils such as linseed-oil and tung-oil. In order to have proper flowing and brushing qualities, all oil-varnishes must also contain volatile-oil solvents which thin the mixtures to such a consistency that they can be applied easily. Without proper thinners the modern wood-finisher can not apply thick varnishes much more smoothly than did the ancient Egyptian who probably used a spatula, trowel, or flat stick for smearing the heavy-bodied preservative finishes over the mummy-cases of his day.

The important thinners or volatile solvents used in varnishes are wood and gum turpentine, various mineral oils such as benzine, also called naphtha 54°, heavy naphtha 41° and 48°, varnolene, kerosene 46°, Texaco spirits, and special thinning compounds containing some of the above-named volatile oils with small quantities of other substances.[18]

187. Turpentine.—The only perfect solvent for varnishes known today is turpentine. Various reports indicate that from 65 to 75 per cent of the world's supply of turpentine comes from the United States. The turpentines made in foreign countries are slightly different in composition from our own product, because the raw materials used abroad are gathered from species of trees different from those that produce the crude turpentine gum in the United States.

---

[18] See Winfield G. Scott, *Formulas and Processes for Manufacturing Paints, Oils, and Varnishes*, pp. 117, 119.

Two kinds of turpentine are manufactured in the United States: (1) gum turpentine, manufactured by distilling a crude gum which is exuded from the longleaf pine (*Pinus australis* or *palustris*) and a few other pine trees of the South;[19] and (2) wood turpentine, obtained thru the destructive distillation from "lightwood" or pitchy stumps or logs, or sometimes thru the steam distillation of wood and the use of volatile solvents, such as gasoline or benzine, for the separation of the turpentine from the rosin.

Gum turpentine is superior to wood turpentine in various ways, particularly in regard to odor; but wood turpentine is often used in varnishes because it is slightly cheaper. Reports indicate that of all the turpentine manufactured in the United States only three per cent is wood turpentine, and the other ninety-seven per cent is gum turpentine.[20] All turpentines bring such high prices at present that varnish-makers are willing to take cheap grades, because even low-grade turpentines are considered preferable to mineral oils such as the various petroleum solvents.

Turpentine consists very largely of alpha and beta pinene, and distils at temperatures from 155° C. to 180° C.[21] In addition to pinene, turpentines contain small amounts of other terpenes, and some other products of oxidation. Wood turpentine contains small quantities of another turpene, known as dipentene. Chemically, turpentine is not inert and inactive as the petroleum oils are; but it combines readily with many substances such as oxygen, chlorin, bromin, iodine, hydrogen chlorid, nitric acid, sulphuric acid, and many other substances which are highly active chemically.[22]

When exposed to the air in a thin film, turpentine becomes oxidized thru absorption of oxygen, and at the same time gives off hydrogen peroxide in small amounts. The absorption of oxygen from turpentine in an uncorked bottle causes the remaining liquid to turn yellow and become more oily and viscous. The boiling-point of turpentine is somewhat raised by the various changes that take place, according to Veitch and Grotlisch, and small quantities of acetic and other acids are produced.[23] Turpentine may turn dark if left in a tin can, because the acids in the oil may attack the iron of the container.

---

[19] See A. C. Newell, *Wood and Lumber*, pp. 67-69.

[20] See Chemical and Metallurgical Engineering Magazine, Vol. XXVII, No. 11, p. 570.

[21] See E. P. Veitch and V. E. Grotlisch, *Turpentine*, Bulletin No. 898, Bureau of Chemistry, United States Department of Agriculture, p. 5.

[22] Ibid., p. 5.

The reason that turpentine is a superior thinner for varnishes and paints is supposed to be largely on account of its ability to absorb oxygen from the air, then to act as a carrier and thus to convey to the drying-oils the free oxygen they so readily absorb. Turpentine also deposits or leaves a certain amount of resinous residue in paints and varnishes, and this material remains in the films of drying-oil as a small amount of solid matter. Turpentine evaporates much more slowly than other oils which are often substituted for it. The slow evaporation of turpentine gives it brushing and flowing qualities that no other oil can give. Benzine dries so rapidly that varnishes containing it must be spread quickly, and with great care, or the films or coatings will show brush-marks and spots that will have to be touched up. It is thought by some wood-finishers and manufacturers that turpentine has more to do with good flowing qualities than aging or even other ingredients in the composition of a varnish.

Turpentine weighs about 7⅕ pounds per gallon at a temperature of 70° F. At 60° F. it weighs from 7.16 pounds to 7.327 pounds per gallon, varying with the specific gravity of different samples of the oil. At 70° F. the variation is from 7.1234 pounds to 7.2896 pounds, and at 80° F. from 7.086 pounds to 7.2515 pounds to the gallon. The above weights are based on a variation of specific gravity from 0.86 to 0.88. The specific gravity of unadulterated turpentine is usually between 0.862 and 0.872 at a temperature of 70° F. The United States Government standard for turpentine requires that at least 90 per cent of the oil shall distil below 170° C. (338° F.). Most turpentines boil at about 160° C. (320° F.), and entirely distil under 180° C. (356° F.) leaving practically no residue.

---

[23] See E. P. Veitch and V. E. Grotlisch, *Turpentine*, Bulletin No. 898, Bureau of Chemistry, United States Department of Agriculture, pp. 5, 6.

Out of the total consumption of turpentine in the United States, about 45 per cent is used by manufacturers for thinning paints and varnishes, and 40 per cent more is used by painters and wood-finishers. The other 15 per cent is used in various industries.

Varnishes vary in the amount of drying-oils in proportion to the turpentine or other thinners contained. Turpentine is now so expensive that it is not often selected as the sole solvent for varnishes. A ''short-oil'' varnish containing 100 pounds of gum and eight gallons of drying-oil would require about 25 gallons of turpentine, while a ''long-oil'' varnish with the same amount of resin and 30 gallons of drying-oils would contain about 32 gallons of turpentine. Sometimes a quick-drying ''short-oil'' varnish is made of 100 pounds of resin, five gallons of drying-oil, and about 38 gallons of turpentine. Such a varnish might be used as a very thin polishing varnish, but it would not be very durable even tho it contained high-grade resins and good drying-oils. Many varnishes at present contain heavy naphtha 48°, benzine, or varnolene in place of part or all of the turpentine.

188. Turpentine Substitutes.—Several mineral thinners are used as substitutes in part for turpentine in many good varnishes. These less expensive thinners have practically replaced turpentine in very cheap varnishes. They cost only one-fifth to one-quarter as much as turpentine, and add fluidity, flow, and brushing-qualities quite similar to those furnished by turpentine. Some manufacturers claim that mineral oils are satisfactory thinners and are practically as good as turpentine in varnishes.

The mineral substitutes are manufactured with the same flash-points and distillation-ranges as turpentine; therefore, they can be placed in hot varnishes at about the same temperature as that used for turpentine. The mixing temperatures are often about 176.6° C. (350° F.), but they may vary somewhat either up or down. The solvent power of petroleum distillates is considerably lower than that of turpentine, rendering the gums in the varnish more liable to precipitation with an excess of thinner.[24] Turpentine gives somewhat better flowing and brushing qualities than can be obtained from the mineral substitutes.

The turpentine substitutes most commonly used in varnish in the United States are: benzine, which is the same as naphtha 54°; naphtha 41° and 48°, varnolene, a Standard Oil Company product; Texaco spirits, manufactured by the Texaco Company; Sunoco naphtha, produced bythe Sun Oil Company; and kerosene 46°. The ordinary naphthas are too volatile for use in varnishes and cause them to set too quickly and to dry too fast.

Turpentine substitutes for varnishes are often made by compounding two or three of the above-named mineral oils. Sometimes a small amount of turpentine, usually wood turpentine if available, is added to the mixture. Moisture and free acid contained in such compounds can be removed by the use of very small amounts of plaster of Paris and slaked lime.

189. Driers and Their Functions in Oils, Varnishes, and Japans.—The drying-oils, such as linseed-oil and tung-oil, do not dry fast enough in varnishes and paints for most practical purposes; consequently, metallic driers are added to accelerate the drying process which is largely chemical in nature and consists to a great extent of oxidation. The substances used to hasten the drying action of oils are salts of various metals. Such salts are called driers or siccatives.

Salts of various metals, such as calcium, iron, and zinc, have at least slight drying properties; but only those from three metals—cobalt, lead, and manganese—are satisfactory for commercial use. Lead and manganese driers are very commonly used in varnishes; but cobalt is rarely used, tho occasionally it is found in the form of a cobalt linoleate, and very recently it has been employed in combination with the acids of other organic oils than linseed.

---

[24] See R. S. Morrell and A. de Waele, *Rubber, Resins, Paints and Varnishes*, p. 190.

The function of a drier is largely that of a catalyser, which in this case means that a siccative acts as an oxygen carrier for the oils, which for a time actually gain in weight.[25] The powerful driers, such as the drying salts of lead and manganese, are said to have the capacity of forming two sets of compounds with oxygen, the first of the newly formed substances having only half as much oxygen as is found in the second or final compound.[26]

According to Sabin, the driers give up half of their oxygen while in the drying-oil; then they absorb an equal amount of oxygen to replace that which was lost, and obtain it from the air. The oils in drying again take oxygen from the driers when they are exposed in films. In this case the driers really act as oxygen carriers from the air to the oil, and increase the rapidity of the oxidation or drying of the film of oil or other finish, such as paint or oil-varnish, which contains the drying oil.

The lead driers seem to be more satisfactory than those derived from managanese, even tho the latter metal is said to have greater oxidizing power. It is known by the chemists that the oxidizing capacity of a drying-oil cannot be correctly measured by its power to absorb oxygen.[27] Morrell thinks that the glyceryl radical has its function in the setting, the oxidation, and the polymerization of drying-oils.

The changes which take place when oils dry are not very clearly understood by the chemists, partly because it is so difficult to study reactions in the films. It is known, however, that the metals which are the most active as oxygen carriers in oils are those that have more than one oxide, and that this is especially true when the lower oxides form salts that are more stable than the higher oxides.

---

[25] See R. S. Morrell and A. de Waele, *Rubber, Resins, Paints, and Varnishes*, p. 70; and G. B. Heckel, *A Varnish Catechism* (Fifth edition, 1927), p. 27.

[26] See Alvah Horton Sabin, *Technology of Paint and Varnish*, p. 114.

[27] See R. S. Morrell and A. de Waele, *Rubber, Resins, Paints, and Varnishes*, pp. 71, 72.

The amount of driers that rosin or linseed-oil will take up before saturation varies greatly with the different drying-salts.[28] One gallon of linseed-oil, which weighs about 7¾ pounds, will absorb 5¼ pounds of lead-acetate crystals, or 3⅒ pounds of litharge, or 3⅙ pounds of red lead, or 1⅕ pounds of manganese dioxide. Rosin will absorb vastly more of the driers before becoming saturated; for example, 100 pounds of it will take up 36.92 pounds of litharge, or 37.40 pounds red lead, before reaching the saturation-point.

The chemical theory of the use of driers as oxygen carriers or catalysts does not seem to take all the reactions into account, and it is evident that part of the phenomena are to some extent physical. There seems to be a greater activity or reaction in a drying film at its surface than elsewhere, and it is probable that a portion of the drier moves to the surface and forms a greater concentration of drying forces just at the place of contact of the air with the film.

The cobalt driers which are sometimes found on the market or which are made in factories are cobalt acetate, cobaltous oxide, cobalt resinate, and cobalt linoleate. Until quite recently cobalt linoleate was the only cobalt drier commonly used, but now combinations of cobalt with some of the other organic-oil acids are considered excellent driers.

The lead salts and compounds used as driers are: litharge, which is lead oxide (PbO); red lead, which is called the sesquioxide (Pb_3O_4); lead acetate, ($Pb(C_2H_3O_2)_2 + 3H_2O$), also called white sugar of lead; lead borate, ($Pb(BO_2)_2$); lead resinate, ($Pb(C_{20}H_{29}O_2)_2$; lead oleate, ($Pb(C_{18}H_{33}O_2)_2$; and lead linoleate, ($Pb(C_{18}H_{31}O_2)_2$.

The various manganese driers that can be used are: manganese dioxide (MnO_2); manganese borate in dry form (MnB_2O_4); managanese sulphate ($MnSO_4 + 4H_2O$); and occasionally manganese chloride ($MnC_2 + 4H_2O$). Besides these, the linoleates, resinates, and tungates of managanese are also used as driers. The manganese driers discolor varnishes but little, being much superior to the lead driers in this respect. The lightest in color of all of the manganese driers are the sulphate and the borate; consequently, these salts are often selected as driers for very pale varnishes.

---

[28] See Winfield G. Scott, *Formulas and Processes for Manufacturing Paints, Oils, and Varnishes*, p. 203.

Umber, a ferric oxide containing manganese oxide and clay, receives its drying properties from the manganese content mainly; therefore, it should be considered as a manganese drier rather than an iron drier. Manganese driers are superior to lead driers in resistance to moisture; and, partly for this reason, they are used in connection with lead driers in water-proof varnishes.

For use in paint mixtures manufacturers often select an oleate of lead and manganese which contains about two parts of lead to five parts of manganese. In fact, oleates or resinates made from the two metals just named are commonly used in driers. Driers containing both metals in compounds are often preferred to those made from one of the metals alone, because manganese driers are said to expand in drying while lead driers react differently and are thought to contract.

Concentrated driers may contain as much as twelve per cent of metallic drying-salts when compounded in liquid form, while weaker driers sometimes are manufactured with only two per cent.

Painters' japans are liquid mixtures of driers, and usually contain a varnish-gum or resin in addition to the other ingredients ordinarily found in driers. The gums used in japan-driers are among the cheapest of the varnish-resins such as rosin especially, and sometimes shellac, and kauri. A present-day thin liquid japan-drier might be made up of 100 pounds of rosin, with ten pounds of manganese dioxide, and 15 pounds each of litharge and red lead, with about 10 gallons of linseed-oil. These materials are given heat treatments similar to those used in manufacturing varnishes, and then the hot liquid is thinned with heavy naphtha 48° after the mixture has been partly cooled.

Another slightly different japan-drier, known as a grinding-japan, and often used as a vehicle for grinding various pigments, is rich in varnish-gums and drying-oils. Such a japan must have a composition that will admit of its being thinned with drying-oil and turpentine. Grinding japans are very strong in lead driers, and cannot be thinned with unlimited quantities of drying-oils without the precipitation or clouding of certain component parts of the liquid.

Shellac grinding japans are made in various ways, one of which is as follows: heat linseed-oil (27 to 30 per cent of the total) to about 115.5° C. (240° F.), and gradually add driers such as red lead, litharge, and manganese dioxide, to about 8⅔ per cent while the temperature is being increased to 232.2° C. (450° F.).[29] About 3½ per cent of orange-shellac of the T.N. (truly native) grade is slowly stirred into the hot liquid after removing the kettle from the fire. The shellac is cooked into the mixture; and, after cooling somewhat, a thinner of wood turpentine and heavy naphtha 48° is added.

---

[29] See A. H. Sabin, *Technology of Paints and Varnish*, p. 121; or Winfield G. Scott, *Formulas and Processes for Manufacturing Paints, Oils, and Varnishes*, p. 98.

TABLE VI.

General Formulas for Oil-Varnish

Class of Ingredients	Name of Ingredients	General and Chemical Information	Amount Used	Special Function in Varnishes
SOLIDS Varnish-Resins or Gums	VARNISH-RESINS (General characteristics)	Resins are free acid gums containing resenes. Resins commonly used are hard fossil gums; or rosin, ester gum, or a mixture. Hard resins are not easily soluble cold. They are heated till reduced sometimes 25% in weight, making them more soluble; and then are mixed with hot oxidizing oils. Usual heat about 287° C. (550° F.).	Varies greatly. Spar-varnishes often have 27 to 48 gallons of mixed oils to 100 pounds of gum. A very short-oil varnish may contain only 4 gallons of oil with 20 gallons of turps to each 100 lbs. of gum.	To furnish solids for films which are about 1/750″ thick. To give resistance to atmosphere and moisture. To produce stableness and gloss. To fill surface cells and stop capillary action. To give hardness to the films.
	PONTIANAK	Melting-point 226° C. (440° F.). Semihard. Milky, yellow to reddish-brown. Partly soluble in turpentine.	In spar-varnishes, about 100 lbs. gum to 30 gallons of oil and 30 of solvents.	To give water-proof qualities to coach- and spar-varnishes. To produce hardness in polishing-varnishes.
	HARD MANILA (Fossil Copal)	Melts at about 242° C. Quite hard. Dull white, yellow-red, or brown in color.	In polishing-varnishes, 100 lbs. gum, 10 gallons of oil, and 36 of solvents.	To produce satisfactory cheap varnishes for inside use. To give good rubbing and polishing qualities to films.

TABLE VI.—Continued

GENERAL FORMULAS FOR OIL-VARNISH

Class of Ingredients	Name of Ingredients	General and Chemical Information	Amount Used	Special Function in Varnishes
SOLIDS Varnish-Resins or Gums	KAURI	Fossil from New Zealand. Medium hard. Melts at 265° C. (509° F.).	For a coach-varnish, 100 lbs. gum, 40 gallons of oil, and 50 gallons of solvent as turpentine.	For durability and to give rubbing and polishing qualities. For use in high-grade varnishes.
	CONGO	Widely used. Fossil. Hard Belgian copal melts at 266° C. Partly soluble in turps and benzine.	For a quick-rubbing varnish, 100 lbs. of gum, 8 gals. of oil, and 25 gals. of solvents.	To produce a very light-colored hard varnish. To give quality and hardness rather than cheapness.
	ROSIN or COLOPHONY	Widely used. Cheap. Melts at 130° C. (266° F.). Slightly soluble in turpentine. Becomes hardened and improved if heated to 200° C. with lime or zinc oxides and becomes a resinate.	For an architectural varnish, 100 lbs. of gum, 30 gallons of tung-oil and 90 gallons of solvent.	To lower the price of varnishes. To produce a very level surface. To use in small quantities in high-grade varnishes to cause them to cure quickly. To make varnish films flow easily.
	ESTER-GUM	Made by heating common rosin with glycerine to 280° C. (536° F.) thus combining part of the abietic acid with the glycerine. Cheap gum used with tung-oil. Melts at 160° C. (320° F.).	For a furniture rubbing-varnish, 100 lbs. gum, 10 gallons of tung-oil, and 30 gallons of solvent.	To furnish a gum in quantity having a less acid reaction than that of rosin. To produce a water-proof varnish with tung-oil that is quite elastic.

TABLE VI.—Continued

GENERAL FORMULAS FOR OIL-VARNISH

Class of Ingredients	Name of Ingredients	General and Chemical Information	Amount Used	Special Function in Varnishes
VEHICLES or DRYING-OILS		Drying-oils form films of a solid elastic nature by oxidation in the air. Linseed and Tung-oil are the typical drying oils. Drying or oxidation can be accelerated by "driers." Drying-oils are "fatty oils" of vegetable origin, and are glycerides which are saponifiable. Oxidation of drying-oils is accompanied by heat and danger of spontaneous combustion under certain conditions.	Varies from about 4 gallons up to 52 gallons per 100 lbs. of resin. Rosin and ester-gum varnishes contain mostly tung-oil with small amounts of linseed-oil.	Drying-oils act as binders for the resins and make varnish-films more elastic. They dry by oxidation instead of evaporation, and make oil-varnishes easy to spread. They can be mixed with almost insoluble resins at high temperature and hold them in solution after cooling.
	LINSEED-OIL	Is a complex mixture of the glycerides of several vegetable acids. Is extracted from flax-seed by pressure. Varies from light yellow to yellowish brown in color. Flash-point is 260° C. Soluble in turpentine and ether. Dries quicker after boiling with driers.	Varies from 8 to 52 gallons of oil to 100 pounds of resin. Long-oil varnishes have 25 to 52 gallons of oil to 100 lbs. of resin. Medium-oil varnishes — 12 to 25 gallons of oil; and short-oil, less than 12 gallons to each 100 lbs. of resin.	Drying or oxidation of glycerides of unsaturated acids. Mixed with resins it forms a tough elastic film which is not easily soluble. It provides proper drying qualities which can be varied by the heat treatment of the oil and the driers used in it.

TABLE VI.—Continued

GENERAL FORMULAS FOR OIL-VARNISH

Class of Ingredients	Name of Ingredients	General and Chemical Information	Amount Used	Special Function in Varnishes
VEHICLES or DRYING-OILS	TUNG-OIL or CHINA-WOOD OIL	Is extracted from the nuts of a Chinese tree by pressure. Dries in two-thirds the time needed for linseed-oil. Durability of treated tung-oil is greater than for linseed-oil. Usually heated to about 205° C. with rosin or linseed-oil to prevent jellying. Most of it is used in rosin-varnishes.	In spar- and marine-varnishes, usually 32 to 44 gallons with 4 to 8 gallons of linseed-oil to 100 pounds of resin. In short-oil rubbing-varnishes, 4½ gallons of tung-oil with 4½ gallons of linseed-oil, to 100 pounds of resin.	It gives unusual durability to varnishes with cheap resins. It is very impervious to water when used even with rosin and ester-gum. It dries harder than linseed-oil, and furnishes hardness to films of rosin-varnishes. It dries very rapidly, and is therefore valuable in quick-drying varnishes.
VOLATILE SOLVENTS	SOLVENTS or THINNERS	They should have a distilling range similar to that of turpentine which boils at 160° C. and is all distilled at 180° C.		Thinners make varnishes more fluid, blend the mixtures of resins and oils, and furnish brushing qualities.
	TURPENTINE (Two kinds: Gum Turpentine and Wood Turpentine.)	Best known varnish solvent, but is not obtainable in the quantity needed. It is used in part as a solvent for most high-grade varnishes, but is not often found in the cheapest varnishes.	With each 100 lbs. of resin when 8 gallons of oil are used about 25 gallons of turps are added. When 30 gallons of oil are used about 32 gallons of turps are added.	It helps in oxidation of the oils. It leaves a slight residue. It gives exceptional flowing and brushing qualities because of slow evaporation.
	NAPHTHA and BENZINE	Various heavy naphthas such as naphtha 41°, 48° and 54° (benzine) are used.	May contain up to 80 gallons in long-oil varnishes, with 52 gallons of oil to each 100 lbs. of resin.	They are used in cheap thinners to add brushing qualities.

TABLE VI.—Continued

GENERAL FORMULAS FOR OIL-VARNISH

Class of Ingredients	Name of Ingredients	General and Chemical Information	Amount Used	Special Function in Varnishes
VOLATILE SOLVENTS (Cont'd)	VARNOLENE and TEXACO SPIRITS	They are heavy naphthas having a boiling-point about like that of turpentine.	Usually between 12 and 48 gallons to each 100 pounds of resin.	They are cheap turpentine substitutes.
	KEROSENE 46°	Solvent for low-grade varnishes.	Used in small quantities, 4 to 16 gallons to 100 lbs. of resin in cheap varnishes, especially baking-varnishes.	Very cheap turpentine substitutes.
METALLIC DRIERS	LITHARGE	Lead monoxide (PbO). Often used with other driers, such as manganese borate, red lead, and lead acetate.	Varies greatly, 1½ lbs. to 16 lbs. to each 100 pounds of resin in varnishes.	To accelerate the rapidity of drying of the drying-oils.
	RED LEAD	Also called minium (Pb_3O_4). Often used with manganese sulphate and borate.	Varies up to 16 pounds per 100 of resins in varnishes.	To act as an oxygen carrier for drying-oils.
	LEAD ACETATE	Also called sugar of lead ($Pb(C_2H_3O_2)_2 + 3H_2O$). Often used with red lead, and manganese borate or sulphate.	Usually about 8 pounds to 100 pounds of resins.	To accelerate the drying qualities of oils.
	MANGANESE DIOXIDE	Black oxide of manganese (MnO_2). Used with red lead and sometimes other driers.	Often 2 to 2½ pounds to 100 pounds of resin in varnishes.	Chiefly to increase the drying of manganese oils.

REFERENCES—CHAPTER XIII

Oil or Oleoresinous Varnishes

HISTORY—PURPOSE—CLASSIFICATION—COMPOSITION

J. Gault Bearn, *The Chemistry of Paints, Pigments, and Varnishes,* pp. 161-249.

Berry Brothers, *Varnish-Gums, Varnishes, and Varnishing.*

Ch. Coffignier, *Colors and Varnishes,* "Oils," p. 152; "Solvents," p. 157; "Driers," p. 171; "Manufacture and Properties of Varnishes," pp. 171-213.

Grand Rapids Wood-Finishing Co., *Better Wood-Finishing.*

G. B. Heckel, *A Varnish Catechism,* Published by American Paint and Varnish Manufacturers Association, Philadelphia, Pennsylvania.

A. Ashmun Kelly, *The Expert Wood-Finisher,* pp. 183-190.

R. W. Linsay, "Manufacture and Application of Varnishes and Enamels," The Painters' Magazine and Paint and Wall Paper Dealer, August, 1925, pp. 49-52.

R. S. Morrell and A. de Waele, *Rubber, Resins, Paints, and Varnishes,* pp. 35-108, 179-212.

A. C. Newell, *Wood and Lumber,* "Turpentine," pp. 67-71; "Rosin," pp. 71, 2.

E. Perry, *Varnishes, Driers, and Drying-Oils* (Contains formulas and methods of manufacture), Published by The Oil, Paint, and Drug Reporter, N. Y., 1927.

Alvah Horton Sabin, *Technology of Paint and Varnish,* pp. 6, 31, 77, 105, 112, 124.

Walter K. Schmidt, *Problems of the Finishing-Room,* Chapter L.

Winfield G. Scott, *Formulas and Processes for Manufacturing Paints, Oils, and Varnishes,* pp. 96-174.

The Sherwin Williams Co., *How Paints and Varnishes Are Made.*

A. E. Stauderman and H. L. Beakes, "Manufacture and Use of Amberol-Type Resin-Varnish," Industrial and Engineering Chemistry Magazine, Vol. 20, No. 7, pp. 674-6.

S. W. Stratton, *Paint and Varnish, Bureau of Standards,* United States Department of Commerce, Circular No. 69.

F. N. Vanderwalker, *Wood-Finishing, Plain and Decorative,* pp. 154-168.

E. P. Veitch and V. E. Grotlisch, *Turpentine,* United States Department of Agriculture, Bulletin No. 898.

CHAPTER XIV

Oil or Oleoresinous Varnishes (*Continued*)

TYPES—PROPERTIES—APPLICATION—RUBBING—REMOVING

190. Types of Varnish.—A complete list of the various kinds of oil-varnishes now used would be long because some manufacturers make over 200 kinds. For the average wood-finisher it seems best to group them into a few important classes based upon use. Following are some of the most important groups of varnishes: architectural, automobile, baking, cabinet, chair and pew, coach, color, dipping, exterior, enamel, finishing, flat, flat-mixing, floor, flowing, furniture, gear and chassis, gloss-oil, grinding, heat-proof, insulating, interior, long-oil, marine, mixing, motor-car, piano, polishing, rubbing, sizing, short-oil, spar, spraying, steel-car, and water-proof.

Varnish-makers vary the ingredients that are selected for incorporating into varnishes according to the purpose for which the varnish is intended. There is no such thing as an "all-purpose varnish," and no one would want such a finish if it could be manufactured.

A brief description of the types of varnish most commonly used by the wood-finisher follows:

191. Architectural Varnish.—This term is used to include varnishes that can be used satisfactorily for decorative work, and also on the interior and exterior of buildings.

192. Automobile Varnish.—Long-oil finishing-varnishes containing about 40 per cent of drying-oils, largely linseed-oil, with hard gums, are used on automobiles and railway coaches.

193. Baking-Varnish.—Such varnishes have compositions which enable them to be dried by heat above normal, usually in ovens. They are intended for use over either wood or metal. Baking-varnishes are most frequently dipped or sprayed on art-metal objects, parts of automobiles, and fine machines, such as typewriters. Temperatures of from 90° to 220° F. are used in the drying-rooms and ovens. Such varnishes contain more than the normal amount of drying-oil, but not more than 24 gallons to the 100 pounds of gum; and when baked on they produce a very elastic finish that is usually durable and smooth. Rosin-varnishes, unless hardened rosin is used, will not stand baking at high temperatures, because rosin softens at about 154° F. (67.7° C.). Most good baking-varnishes will stand a temperature of 160° F. for an hour. A hardened dammar-varnish will stand baking at 220° F. Congo and kauri varnishes are not injured by a temperature of 180° F. No oil-varnish will endure a temperature of 300° F. without turning yellow.

194. Coach-Varnish.—At present this term means an architectural varnish, but formerly it referred to a fine grade of carriage or railway-car varnish.

195. Exterior Varnish.—This name is given to oil-varnishes which are intended for outdoor use on doors, stores, and the exteriors of buildings. They are made to resist the elements of destruction under exposed conditions, and contain more than the usual amount of drying-oils.

196. Enamel-Varnishes.—Specially prepared varnishes are manufactured for use in enamels. Formerly, very white or transparent varnishes manufactured from dammar-gum as a resin were selected for use in white enamels, because such varnishes do not contain linseed-oil which may turn yellow with time. Enamel-varnishes, especially those made for use with white enamel, must be without color when new, and should not discolor with age. Dammar-varnishes are not durable, and are going out of use, because satisfactory, clear, and transparent oil-varnishes which are durable have been prepared recently for use in even the whitest enamels.

Varnishes intended to be used with white enamel are generally of the short-oil type, and are often made from properly treated rosin and pale magnesia linseed-oil. A better varnish for enamel manufacture, however, is a short-oil, pale, ester-gum compound.

In order to secure very perfect leveling qualities and durability, manufacturers generally select long-oil varnishes that are made by the use of low heat and a short cooking of pale oils and a pale gum, such as glycerine rosin which is manufactured from a water-white rosin. The cooking of such varnishes should be done in an aluminum kettle to prevent the discoloration which is apt to follow heating in an iron or copper kettle. Long-oil varnishes for use in enamels sometimes contain as much as 40 gallons of drying-oil to each 100 pounds of varnish-gum.

The varnishes used in baking-enamels are medium-oil varnishes. It has been found that quick-drying varnishes which contain 24 or more gallons of drying-oil to each 100 pounds of rosin cannot be used, because this excess of oil causes the enamel to lose its gloss or even to become wrinkled during the baking process. Some of the varnishes which are made for use with baking-enamels contain China-wood oil, others contain linseed-oil, and in still others both oils are found.

Many of the black varnishes used in baking-enamels are manufactured from special gums, such as gilsonite, parolite, asphaltum, and manjak. The favorite black gum seems to be gilsonite, a brittle black substance which produces a very high luster. The black baking-varnishes are manufactured thru heat treatments of the special black gums, usually with manganese-treated linseed-oil. The thinners commonly used in compounding these black varnishes are 46° kerosene and 54° benzine.

197. Finishing-Varnish.—This term refers to a last-coat varnish for furniture, such as pianos, and for carriages and automobiles. These varnishes are manufactured with such a composition that they can be rubbed lightly with pumice-stone, yet be more tough and elastic than the other coats under them. Finishing-varnishes have a medium-oil composition, and can be polished to a high gloss. Some finishing-varnishes for use on railway coaches have as much as 50 per cent of drying-oils and are very durable.

198. Flat Varnish.—The name flat varnish is given to varnishes that dry without luster, sometimes producing what is called a ''matt'' surface which is dull. They are intended for final coats for furniture, and produce a soft attractive effect without the expense of hand or machine rubbing. Flat varnishes are manufactured in various ways. One method is to add to a varnish containing tung-oil some aluminum-stearate jelly, which is made from aluminum-stearate heated with turpentine and then cooled. Tung-oil itself under certain conditions has a tendency to make a ''flatted'' effect. Aluminum stearate has remarkable qualities for destroying gloss, but it must be used with turpentine rather than benzine as a solvent; and, if used in excess it may cause the varnish to ''liver'' or become thick.

Some flat varnishes are made from a soft black East India gum melted at very low heat, sometimes at about 150° F. or 175° F. (73.9° C.). This low-temperature melting process, sometimes called ''slack melting,'' destroys the luster of the gum unless higher heat of 200° F. to 300° F. (148.8° C.) is used later. In such a case the soft East India gums treated with high heat will produce gloss-varnish similar to that manufactured from gum from the Congo when a heat of about 550° F. (287.7° C.) is used in cooking the varnish.

Some of the ''Satin Finishes'' are flat varnishes which are made entirely from the soft East India gum. Such a varnish is quite soft, and is affected by heat at about the same temperature as that which will tend to soften rosin-varnish. In order to secure reasonable hardness, a certain amount of hard-gum varnish is added to the ''slack melt'' soft-gum varnish; yet a flat effect is left if the proper proportion is used and the mixture is hard enough for satisfactory service. Some manufacturers claim that the best flat varnishes are made from gloss varnishes which are ''flatted'' by the use of aluminum stearate. Occasionally, zinc stearate is used in place of aluminum stearate.

Flat varnish should not be made by adding beeswax to a gloss varnish, because the flatness secured from the wax is not permanent, and additional coats of varnish will not adhere well if it is ever necessary to refinish the surface. Wax finishes must be entirely removed with turpentine, gasoline, or benzol, and sanding before revarnishing is attempted. It is very difficult to remove the wax from a varnish-wax or a varnish ''flatted'' with wax after it is spread on a surface except thru a laborious sanding operation or the use of varnish-removers.

199. Flat Mixing-Varnish.—Mixing-varnishes that will dry flat belong to a rather new type. They are used to mix with pigments, especially lithophone, in the manufacture of flat wall-paints for indoor use. The flat varnish helps in binding the pigments together; yet it gives no luster or gloss. Flat enamels are also ''flatted'' thru the use of flat mixing-varnishes. Ordinary ''gloss'' mixing-varnishes are often made from heat-treated tung-oil, with relatively small amounts of other varnish ingredients, such as rosin, driers, and thinners. Mixing-varnishes are made into flat mixing-varnishes by the addition of aluminum-stearate jelly and turpentine, stirring the latter substances slowly into the mixing-varnish at ordinary temperatures.

Mixing-varnishes for use in paints have a high content of drying-oils, largely Chinese-wood oil (tung-oil), the amount often varying from about 25 per cent to 45 per cent of the total weight of the ingredients. On the other hand, mixing- and grinding-varnishes for use in enamels are generally ''short-oil'' varnishes and are not as durable for outside use.

200. Floor-Varnishes.—In order to be satisfactory for finishing floors, varnishes must have several of the important characteristics of spar-varnish; yet they should have only a medium-oil content, and must dry hard enough over night to make walking on them possible, and, finally, they should dry much harder than spar-varnishes do. Floor-varnishes must be elastic and tough in order that they may be scratched as little as possible under the furniture.

Sometimes floor-varnishes are made by blending together other varnishes. In composition floor-varnishes often have a drying-oil content of about 35 to 38 per cent, the oil used being largely tung-oil. This amount of oil with properly treated gums, driers, and thinners, produces varnish that is largely water-proof and which does not turn white with water even tho rosin be used as the chief or only resin.

Floor-varnishes are sometimes used for inside finish of buildings, such as the ''trim'' and stairways, but they are often objectionable for use on light-colored unstained woods because they may be too dark in color.

201. Flowing Varnish.—Whenever a high gloss is desired without rubbing and polishing, a flowing varnish should be selected—at least for the last coat. Such a varnish when flowed freely over a surface will not show brush-marks because it will level itself tho the coat be rather thick; consequently, such a finish is not apt to show runs and sags. Flowing varnishes do not set very quickly; and, largely for this reason, they dry with a very smooth lustrous appearance which is devoid of all brush-marks.

202. Furniture-Varnishes.—There are many grades of varnish that might come under this classification. Such varnishes must dry very hard and quickly, and give a brilliant luster when rubbed and polished. In general they are short-oil varnishes containing often only about 13 per cent of drying-oils—partly tung-oil, and partly bleached heavy-bodied linseed-oil. Some of the hard gums, such as hard manila resin or a mixture of rosin and kauri, are preferable to the soft gums in the manufacture of furniture-varnishes.

203. Gear and Chassis Varnish.—The running-gears of wagons, carriages, and automobiles require varnishes that are unusually elastic and durable, and which are able to resist the destructive action of water, lubricating-oil, grease, and road-oil. Such varnishes are usually applied over pigment undercoats containing coloring-matter.

204. Gloss-Oil Varnish.—This group of short-oil varnishes represents a very cheap mixture of ingredients of low grade.[1] Gloss oils are used for sizing canvas, plastered walls, and ceilings, for grinding barrel paints, and as blending varnishes with grinding-oils for barn and freight-car paints. Some of the gloss oils are employed as grinding mixtures for use in baking-enamels and varnishes to add luster to the finishes.

The composition of gloss-oil varnishes varies, some mixtures having ingredients that blend well with turpentine-varnishes, while others are of such a nature that they should be used with benzine-varnishes. Gloss oils are really low-grade quick-drying varnishes, manufactured from rosin, cheap thinners, such as benzine or kerosene 46°, with driers, and sometimes relatively small amounts of drying-oils. They are quite similar in composition to some of the cheap short-oil varnishes, and dry with great rapidity usually becoming hard in from about 20 to 50 minutes. Gloss oils are rich in rosin and contain driers and drying-oils in small amounts. Many gloss oils are made from rosin, slaked lime, a thinner, and sometimes caustic soda.[2]

205. Grinding-Varnishes.—Grinding-liquids are hardly true varnishes because they often contain little or no rosin or other varnish-gums and, in this case, they resemble japans more than varnishes. When they contain rosin they are somewhat similar in composition to gloss oils, but they are relatively weak in rosin.

Grinding-varnishes and japans are used as liquid grinding-mediums for grinding various paint and varnish pigment-colors. They must be of such a composition that they will blend well with pigments, and the various thinners and driers used in japans and gloss oils, which are similar in general composition to the grinding-varnishes. The chief uses of grinding-varnishes, grinding-japans, and gloss oils are quite different, however.

---

[1] See Winfield G. Scott, *Formulas and Processes for Manufacturing Paints, Oils, and Varnishes*, pp. 122-127.

[2] See also Section 216, "Sizing-Varnishes," p. 262.

A neutral grinding-varnish that will dry very hard may be made from glycerine rosin, tung-oil, metallic driers, such as manganese borate and litharge, and a thinner—heavy naphtha 48° often being selected for the purpose. Linseed-oil is also used in connection with tung-oil, and a more expensive solvent such as turpentine, especially wood turpentine, may replace part of the heavy naphtha.

Grinding-japans and grinding-varnishes can not be very clearly distinguished from each other judging by the ingredients.[3] Many grinding-japans, however, contain shellac as the resin, while grinding-varnishes are commonly made from rosin, and contain smaller amounts of metallic driers. The distinguishing feature between grinding-japans and grinding-varnishes is in the relative proportion of the ingredients used—the grinding-japans containing vastly more driers than are found in grinding-varnishes.

206. Hard-Oil Varnish.—This name represents an old type of varnish that came into use a few years ago in an imitation of a rubbed linseed-oil finish. Hard-oil varnish is a term which is now given to almost any cheap varnish that is suitable for interior use only.

207. Heat-Proof Varnish.—Machinery and surfaces that are liable to become heated require a rather unusual quality which resists heat. Such varnishes often contain menhaden oil, or some other fish-oil, because these oils are not so easily affected by heat.

208. Interior Varnish.—Such varnishes are intended for use on the inside of buildings. Various varnishes are selected for this purpose, such as cabinet varnish, interior coach, hard-oil finishes, interior spar, spirit-varnishes, such as shellac and dammar, flat varnishes, and possibly enamels which are hardly true varnishes.

---

[3] See discussion of grinding-japans and gloss oils, under Section 204, "Gloss-Oil Varnish," p. 257.

209. Insulating Varnish. — Electric conductors, especially insulated wires, often need added insulation in motors, generators, and other electric machines in order to prevent short-circuits. Shellac and some types of varnishes, often baking-varnishes of low electric conductivity are used as insulating varnishes.

210. Long-Oil Varnish.—Any varnish that has a rather large proportion of drying-oil relative to the gum is known as a long-oil varnish. An excess of drying-oil retards the drying of a varnish, but makes the film much tougher and more elastic. Spar-varnishes are long-oil varnishes. A varnish with 39 per cent of drying-oil would be ranked as a typical long-oil varnish. The amount of drying-oil contained in long-oil varnishes varies in the formulas from 25 to 52 gallons of such oils to each 100 pounds of resins.

211. Marine Varnish.—Steamboats, yachts, motor-boats, canoes, and all craft and utensils intended for use about or in water, especially salt water, or which are exposed to marine atmosphere, require a special varnish designed to withstand such conditions. Marine varnishes are long-oil varnishes, sometimes called spar-varnishes. They often contain about 38 per cent or more of drying-oil—largely tung-oil, together with smaller quantities of linseed-oil. Some of the hard gums are desirable as ingredients for use in marine varnishes, but rosin properly treated with tung-oil may be used successfully.[4] A good marine varnish should have a high luster, dry in about eight hours, and finally become very hard and water-proof. Such a varnish contains about 48 gallons of drying-oil to each 100 lbs. of gum.

212. Mixing-Varnish.—In order to add luster and hardness to paints and enamels, certain types of gloss varnishes are mixed with them. Varnishes adapted to this purpose are known as mixing-varnishes, and contain no objectionable ingredients that prevent them from forming satisfactory mixtures with paints or enamels.

---

[4] See Winfield G. Scott, *Formulas and Proceses for Manufacturing Paints, Oils, and Varnishes*, p. 130, No. 1702.

Mixing varnishes for use in paint, especially for outside use, are long-oil varnishes containing a large amount of tung-oil; while varnishes for use in enamels are apt to be short-oil varnishes, usually containing less than 12 gallons of drying-oil to each 100 pounds of gum.[5] The short-oil mixing-varnishes often contain about eight to ten gallons of drying-oils to each 100 pounds of resins, which may be of various kinds, such as water-white rosin, Japan rosin, kauri seeds, East India Nubs, or hard Manila gum. Cheap short-oil mixing-varnishes may, however, be made in which only about two and one-half gallons of China-wood oil are used as the drying-oil, with 100 pounds of rosin prepared with proper driers.

Enamel mixing-varnishes of the long-oil type for use in enamels containing colored pigments are sometimes made with as much as 36 gallons of drying-oils, mostly China-wood oil, to each 100 pounds of varnish-gum.

213. Piano-Varnishes.—The high luster and brilliant effect of surfaces which can be perfectly leveled and polished necessitate the use of special varnishes which dry with great hardness and possess unusual flowing and rubbing qualities. High-grade polishing-varnishes, manufactured from hard gums, such as congo, together with special polishing-oils, largely tung-oil treated with rosin and driers, are often used as piano-varnishes. Such varnishes should dry very hard, and are usually "short-oiled," some of them containing only six gallons or less of drying-oils to 100 pounds of gum. Piano-varnishes are finishing or last-coat varnishes; consequently, they should be tougher and more elastic than is necessary in case of undercoat varnishes.

214. Polishing-Varnishes.—Very hard varnishes that will take a high polish after being rubbed with pumice-stone and polished with rotten-stone, are known as polishing-varnishes. They are preferably manufactured from hard gums such as congo, kauri, hard manila, or pontianak.

---

[5] See also Section 199, "Flat Mixing-Varnishes," p. 255.

While polishing-varnishes are similar to rubbing-varnishes, they are usually harder, and are of such a composition that it is possible to give them a more permanent and higher polish. Polishing-varnishes are made for inside use and must be very hard; therefore, they are preferably of the short-oil type, containing from five to eleven gallons of drying-oils to each 100 pounds of resin, mostly the hard-gum type tho 10 to 20 per cent of rosin is often mixed with the more expensive gums.[6] Polishing-varnishes are finishing-varnishes that are to be used over other varnishes.

215. Rubbing-Varnishes.—Undercoat varnishes that are hard and rather heavy-bodied, and which are suitable for rubbing with either water or rubbing-oil without softening or other damage, are called rubbing-varnishes. Congo gum, a hard resin of excellent abrading qualities, together with China-wood oil as the chief drying-oil, are favorite ingredients for use in manufacturing rubbing-varnishes. Other hard gums such as kauri and pontianak are also used. Various amounts of hard rosin or pale ester-gum are sometimes incorporated into rubbing-varnishes with the hard gums, together with varying proportions of linseed-oil which is often properly treated manganese-oil.

Rubbing-varnishes dry rather slowly, usually, because they contain small amounts of driers. Long-oil varnishes are too soft, and do not rub well because they gum up. Rubbing-varnishes are usually of the short-oil type, but they must be so compounded that they will not cloud or turn white when rubbed with water and pumice-stone. Rubbing-varnishes are rather brittle, and must not be spread on top of softer more elastic varnishes, such as spar-varnishes, because some form of cracking is liable to occur if this is done.

Varnishes which are not true rubbing-varnishes can usually be rubbed with sandpaper or pumice-stone sufficiently to remove the gloss and permit of the application of another coat.

---

[6] See Winfield G. Scott, *Formulas and Processes for Manufacturing Paints, Oils, and Varnishes,* Formulas Nos. 1919, 1936, 1954, 1955, 1971, 1972, and 1977.

216. Sizing-Varnishes.—In order to seal up the pores of plastered walls and stop the penetration of paints, low-grade varnishes are sometimes used instead of glue-sizing. The varnishes selected for this purpose are cheap rosin mixtures, which are often called gloss oils.[7] Such sizing-varnishes are manufactured from rosin with heat treatments, and thinned with benzine and sometimes kerosene 46° as solvents. Small amounts of drying-oils are contained in some, while other formulas contain no oils except the solvents.[8]

Sizing-varnishes dry very rapidly—the time required often being about 45 minutes, the slow-drying kind hardening in two or three hours. The rosin is given heat treatments similar to those used in manufacturing other varnishes. Slaked lime and sometimes caustic soda in small quantities are heated with the rosin to neutralize the acid in the gum and harden the rosin itself.

Temperatures of from 260° C. (500° F.) to 287.7° C. (550° F.), or slightly higher, are sometimes used in melting the rosin with the lime, caustic soda, and driers if any are used. If a drying-oil is used it is also heated with the rosin. The thinners are added as the melted mass cools down—kerosene at about 232.2° C. (450° F.), or slightly less, and naphtha 54° (benzine) at about 160° C. (320° F.).

217. Short-Oil Varnishes.—If a varnish contains less than about twelve gallons of drying-oil to each 100 pounds of gum, it is classed as a short-oil varnish. Many varnishes manufactured for inside use, such as rubbing-varnishes, are of this type. Various kinds of gum are used, and the other ingredients contained in short-oil varnishes are similar to the materials ordinarily found in medium-oil and long-oil varnishes. Some of the quick-drying short-oil varnishes contain only three and one-half to four gallons of drying-oils, such as tung-oil and linseed-oil, to each 100 pounds of resin. Varnishes for use in white enamel are sometimes of this type. Such varnishes will not cause white finishes to turn yellow with the lapse of time, because they contain little linseed-oil, the usual cause of discoloration.

---

[7] See Section 204, Gloss-Oil Varnish, p. 257.

[8] See Winfield G. Scott, *Formulas and Processes for Manufacturing Paints, Oils, and Varnishes,* No. 1601, p. 122; and No. 1613, p. 124.

218. Spar-Varnish.—A typical long-oil varnish, which is highly resistant to dampness and the destructive action of water, has been made for many years for coating the spars of ships, hence the name, spar-varnish. Elasticity, toughness, and resistance to water are its chief characteristics. Spar-varnishes dry slowly, do not become very hard, and possess only a moderate luster. They are intended for outdoor use, about windows, sinks, in bathrooms, and wherever resistance to moisture is necessary.

Hard gums, especially pontianak, are preferable for manufacturing the best grades of spar- and coach-varnishes. Cheaper gums, such as hardened rosin and ester-gum, together with heat-treated China-wood oil, are also sometimes used in the manufacture of cheap spar-varnishes.[9] During recent years China-wood oil (tung-oil) has very largely displaced linseed-oil in the manufacture of some spar-varnishes which usually contain a very high percentage of drying-oil. Tung-oil gives water-resisting and quick-drying qualities, while linseed-oil is more elastic and enduring under extreme variations in temperature especially for outside exposure. For these reasons, a blend of the two oils is preferred for use in varnishes for outdoor use. Tung-oil is more expensive than linseed-oil, and is used in spar-varnishes because of its excellent qualities, and not as an adulterant.[10]

219. Spraying-Varnishes.—Many factories which formerly used the brush method of applying finishes have introduced the air-gun pressure process which is rapidly displacing the slower hand method. In order to apply varnishes effectively, special spraying-varnishes are available, which are, in general, very similar to other varnishes, but often somewhat thinner. Many of the ordinary brushing-varnishes can be used satisfactorily with an air-gun. Other varnishes should be thinned with turpentine if they are too heavy bodied.

---

[9] See Winfield G. Scott, *Formulas and Processes for Manufacturing Paints, Oils, and Varnishes,* No. 766, p. 34; No. 1702, p. 130; No. 1773, p. 148; and No. 1795, p. 153.

[10] See discussion of "China-Wood Oil" under Section 186, p. 234; and "Flat Mixing-Varnish," Section 199, p. 255.

The turpentine should be added several hours before using the varnish or it will not become well incorporated into the mixture. It is preferable, however, to thin varnish with ready-prepared very thin varnish that has been mixed with additional turpentine several days previously. In the manufacture of varnish, turpentine is poured into the mixture of gum and drying-oils while the ingredients are still very hot, often at temperatures of about 210° C. (410° F.). In this way the turpentine is thoroly blended into the mixture. Varnishes also should age for several weeks or months before use in order that there may be a perfectly homogeneous mixture when they are used. Some varnishes need additional stirring before use. For the reasons just given, it will be understood that, if varnishes are thinned for spraying, all mixtures must be thoroly stirred and a reasonable amount of time given in order that the cold turpentine may become properly incorporated into the complex mixture of materials which are usually put together when at a high temperature.

Spraying-varnishes and dipping-varnishes should have a viscosity within the range 8 to 16, measured by the Scott Viscosimeter, while brushing-varnishes come within the numbers 16 to 24, tho they often can be applied with a brush with a viscosity of about 36.

220. Water-Proof Varnishes.—Long-oil varnishes manufactured from a hard gum have been considered the only good water-proof varnishes in the past. Since China-wood oil has become known to the varnish-makers, the kind of gum used has become less important. Formerly, it was thought that rosin-varnishes were unfit for exposure to water, but it has been discovered that rosin, properly heat-treated, with China-wood oil in large quantities, can be used in water-proof varnishes.

Ester-gum, which is a synthetic gum, made by treating rosin with glycerine at a temperature of about 275° C. (527° F.), is superior to treated rosin as a gum for water-proof varnishes.[11] The films of varnishes manufactured from ester-gum and China-wood oil are water-proof, and will not turn white in water. A long-oil varnish consisting of 100 pounds of ester-gum and 40 gallons of China-wood oil, heat-treated at from 275° C. (527° F.) to 296.1° C. (565° F.) for from 15 to 30 minutes will be water-proof, and gas-proof if the higher temperature is used.

A long-oil varnish from ester-gum and linseed-oil is also reasonably water-proof. Short-oil and many medium-oil varnishes which contain rosin as the chief gum are very apt to turn white in water. Some varnishes that contain considerable hard gum, especially pontianak gum, are somewhat water-proof, tho ranked as short-oil varnishes which contain less than 12 gallons of drying-oil to each 100 pounds of gum.

221. Working and Thinning Properties of Varnishes.—The working properties of varnishes vary greatly with their composition, the method of application, and the temperature of the air in the room or place where the varnishes are being applied. In addition, the conditions for work, such as a clean room containing as little dust as possible, a clean brush which has not stood in the varnish a long time, clean varnish which has not stood open in a dusty room, and clean, properly-dusted surfaces—all enter into the problem, and affect the success of a job of varnishing.

Varnishes are judged as to their working characteristics by variations in reaction after application, such as the following: (1) flowing qualities, (2) leveling properties, (3) time of setting, (4) ability to stay in place, and (5) thickness of the film.

The *flowing qualities* are felt by the finisher when the brush does not stick or pull, even with a reasonable amount of brushing.

---

[11] See discussion of Ester-Gum, under Section 184, p. 229.

Good *leveling properties* are shown when a varnish can be cross-brushed twice; yet possesses enough fluidity to flatten out leaving no brush-marks.

The *time of setting* varies with the temperature. Varnishes set quickly on a hot day, or if artificially warmed. They are stiff, and do not spread well, if colder than about 70° F. The amount of time required in cross-brushing a varnish film until it will no longer flatten out to a level surface free from brush-marks shows the time of setting.

Staying in place is an important property of a varnish; otherwise, vertical and oblique surfaces show sags, runs, and other defects which unfortunately appear on varnish films that do not stay where they are placed.

The *thickness* of a varnish film is sometimes called its "fullness," or measurement of "body." Long cooking and high temperatures change the characteristics of an oil-gum mass. High temperatures and long cooking require more thinner, and a varnish so made will spread out into a thin film and possess less "body" or "fullness." The thinner itself practically all evaporates; therefore, a varnish containing a large amount of thinner brushes on a surface in a very thin film.

The mixing properties, or amount of thinner that a varnish will incorporate into itself and remain clear, vary depending upon the amount of drying-oil in the varnish. In general, long-oil varnishes absorb turpentine, benzine, and benzol freely. Short-oil varnishes become cloudy, or the gum may be precipitated, if an excess of benzine be used as a thinner. Turpentine can generally be used in almost any desired amount without affecting the gum in the varnish solution. Many varnishes contain light naphtha, which is called 54° benzine, or the heavier naphtha 48°; but these thinners can be added only in limited amounts to varnishes if they are cold, especially below 70° F.

222. Luster, Elasticity, and Color of Varnishes.—These qualities are given to varnishes largely by the materials used in manufacture, tho cooking may modify them somewhat, especially in the color.

Luster in a varnish depends largely upon the gums or varnish-resins incorporated into the mixture for heat treatment in the manufacturing process. Rosin seems to give a higher gloss than any other gum used in varnishes, but it is not durable unless heat-treated and neutralized somewhat with lime or some other flux, in order to reduce its acidity and harden it. Heat treatments of rosin or other gums with oils in varnish-making reduce the luster to some extent, especially if high temperatures be used.

Elasticity in a varnish comes largely from the drying-oil constituents, especially being dependent upon the amount of drying-oils in the mixture, and somewhat upon the kind of gum or gums selected. Ester-gum is preferred to hardened rosin where an elastic varnish is desired. Long-oil varnishes are considerably more elastic than are short-oil varnishes. Many of the elastic varnishes are made with about 35 gallons of drying-oil, usually linseed-oil, to 100 pounds of gum—hard manila or pontianak gum being preferred. Elastic varnishes are intended chiefly for outside use, because they are less affected by the weather, and allow slight changes in expansion or contraction of the surfaces without checking or cracking of the finishing films.

Color in varnishes is due to colors in the gums, the drying-oils, and sometimes to the driers that are used. High temperatures and prolonged cooking darken varnishes, and are avoided in the manufacture of pale varnishes. Pale varnishes are made of pale gums, very light-colored drying-oils, and driers that do not discolor, umber especially being avoided.

223. Necessary Preparations for Varnishing.—This discussion has made it clear that there are many kinds of varnishes, and that the ingredients which are incorporated into these oleoresinous finishes are numerous and vary greatly in cost and quality. Some varnishes are suitable for one purpose, but are not satisfactory for certain other uses.

Water-proof long-oil varnishes should not be applied to furniture, because they dry too slowly, are too soft, lack high luster, and do not rub well. Short-oil varnishes which dry hard and quickly, and have a brilliant luster, are preferred by the furniture-finisher. The wood-finisher's problem at first is the selection of a suitable varnish.

The experienced wood-finisher is particular about the brush or brushes used in spreading varnish. A brush of the proper size, with well-set bristles of medium stiffness, should be selected. Either flat or oval-shaped brushes may be used; oval brushes being preferred for large surfaces where big brushfuls of varnish are necessary for rapid work. An old brush which has been used with paint or shellac is unsatisfactory. Even a high-grade new brush, "set in rubber," requires preliminary treatment before it is ready for use on a last-coat job of varnishing. A new brush should have the dust and loose bristles removed before it is fit for varnishing. It is best to use a new brush for undercoat work for a while, until all loose bristles are removed or fall out; then, after a careful cleaning in turpentine, it is ready for finishing work.

All surfaces should be examined to find out whether they are properly dry before varnishing is begun. Trouble is almost sure to follow if one applies a second coat of finish over a partly-dried undercoat.

Dusting and cleaning the object to be varnished just before varnishing is begun are very important operations that the amateur may overlook. Dust is continually settling, and should be removed just before spreading the varnish. If there is much dust on a piece of furniture or some other object which is to be varnished, it is preferable to take the article away from the varnish-room for dusting, in order to avoid scattering dust into the air of the finishing-room; because some of it is very apt to settle on a newly varnished surface and spoil the finish.

After removing the loose dust with a dusting-brush, the surfaces should be wiped with a piece of cheese-cloth or chamois-skin dampened with water. A piece of muslin or cheese-cloth may be dampened with benzine or turpentine for cleaning a surface which has an undercoat on it, or a "tack-rag" may be made by dampening a dustless and lintless rag in very thin varnish. Such a "tack-rag" if nearly dry, will take up all dust and leave a surface ready for varnishing. All fragments of sand and dust must be removed from the cracks, corners, and pockets in the cells of the wood, or these waste particles will be dragged out by the varnish-brush in flowing on the varnish, and will spoil an otherwise perfect finish.

Old surfaces which are to be revarnished should be washed thoroly with moderately strong soapy water, then rinsed and wiped, preferably with a chamois-skin dampened in clear water. After washing and drying, all old varnished surfaces which are to be refinished should be smoothed down with fine sandpaper which also removes the gloss; then they should be carefully dusted and wiped to make them clean and dustless.

Old wax-finishes, or surfaces that have been treated with a varnish-remover containing wax, should be cleaned properly with benzine, turpentine, or even high-test gasoline. Such surfaces should be wiped, after treatment with the wax-solvents, in order to remove all traces of wax. New films of varnish will not adhere satisfactorily to surfaces having even a small amount or a very thin layer of wax upon them.

The finishing-room and the clothes of the wood-finisher should be as free from dust as possible. Sometimes the floors in finishing-rooms are sprinkled with water to lay the dust. The rooms should be dry, however, because varnish does not dry well on damp days. When the weather is damp or rainy the windows of the finishing-room should be closed. Ventilation without drafts is desirable because fresh air helps oxidation of the drying-oils in the varnish, and speeds up the evaporation of the solvents and thinners.

The temperature of a varnishing-room during the winter time should be between 70° F. and 80° F., and certainly never below 60° F., because warm varnish spreads more satisfactorily. If varnish has been seriously chilled by exposure to very cold weather, it should be warmed by placing the container in warm water, and finally strained, particularly if it is not properly mixed or has separated into its original ingredients to some extent.

Varnish should not be thinned by the finisher, because the manufacturers put as much thinner in the mixture as it will stand and yet give satisfactory service. If a thinner varnish is required, the container may be placed in warm water, or a small amount of turpentine added. If thinner is added to a varnish, at least twelve hours should be given in order that the ingredients may become properly mixed.

224. Application of Oil-Varnishes. — Experienced finishers flow all oil-varnishes over surfaces with the point of the brush. The brush should be held in a position nearly perpendicular to the work, but leaning slightly in the direction of the brush-stroke. At the beginning of a varnishing operation the brush should be well loaded, dipping it far enough into the varnish to cover most of the bristles, and wiping off the excess varnish from the brush in order to prevent dripping. One should, however, remember to avoid unnecessary wiping of the brush, especially on the side of the container, because this operation allows air-bubbles to enter the varnish in the brush. A clean wire stretched across the top of the container makes the best possible wiper for removing excess varnish from a brush.

Varnish should be applied by using brush-strokes with the grain of the material which is being finished. Slow-setting varnishes are often cross-brushed, and then evened over lengthwise of the grain. After a varnish has begun to stiffen, it should not be brushed because, under this condition, brush-marks made in the film will always show.

Panels should be varnished by starting with a brushful of varnish near the middle of one end of the panel. The ends and corners should be covered; then the varnish on the entire panel may be cross-brushed, and finished by using light strokes lengthwise of the grain, with a brush containing only a small amount of varnish. It is good practice to spread the soft varnish film from the middle toward the ends of the panel when doing the final brushing lengthwise of the grain; always using long, rather light strokes, in order to leave the surface in as smooth a condition as possible.

Many varnishers do not use the cross-brushing method. They spread the varnish lengthwise of the grain, and rebrush the entire surface in the same direction after a few minutes, in order to remove the bubbles, and to make sure that the entire surface is evenly covered with a thin coat of uniform thickness.

First coats of a heavy-bodied varnish, when used as undercoats, usually should be thinned with from 14 to 25 per cent of turpentine. Varnish rather than shellac undercoats should always be used whenever the object is to be exposed to dampness, because shellac is very apt to turn white if it comes in contact with moisture. The preliminary coat is really only a durable sizing, which has the function of stopping the capillarity of the wood cells and making a foundation for later finishing-coats.

Second coats, or any of the later coats of varnish, must never be applied to a surface until the undercoats are absolutely dry; otherwise there may be cracking, checking, flaking, or ‘‘crazing’’ later on. Varnishes must never be applied over undercoats of any kind without removing the gloss, because varnishes do not adhere properly to such surfaces. The gloss of the undercoats should be removed by the use of No. 00, No. 000, or No. 0000 sandpaper, always applied with the grain, and held over the fingers or stretched over a soft felt pad. Fine steel wool or pumice-stone is sometimes employed to cut off the gloss of undercoats. All traces of sand and dust from the undercoats must be removed before revarnishing is attempted.

While it is true that undercoats should be applied in thin coats and spread about as thin as possible in covering the surface, it should be noted that any succeeding coats may be somewhat thicker, and should not be brushed out as thin as possible with a dry brush. On vertical or oblique surfaces the varnish must be flowed on in a thin coat, because an excessively heavy coat may show sags or tear drops. All runs and sags can be caught and brushed out with the grain if the varnisher inspects his work and touches it up every few minutes.

Wrinkling is usually the result of applying too much varnish, especially on horizontal surfaces. Thick films or coats of varnish do not dry evenly from top to bottom, because the outside layer forms a skin, and expands thru the taking on of oxygen before the lower or inside portion of the film hardens. Wrinkles are the result of the expansion of the outer skin of a film, which hardens or oxidizes and expands while the lower portion is still soft.

Three or four coats of varnish are often applied if a satisfactory finish is expected, the varnish being spread out thin by careful work with the brush.

The covering-power of varnishes varies greatly, being modified by the temperature, the amount of drying-oils and thinners, and also by the skill of the finisher. Spar-varnishes, which are long-oil varnishes, will spread out over considerable surface, usually from 500 to 550 square feet to the gallon for one coat. If floor-varnishes are spread thin, they will usually cover from 450 to 500 square feet to the gallon. Flat varnishes are apt to be rather stiff, and one gallon often covers only 400 to 450 square feet.

RUBBING THE COATS OF VARNISH

Special varnishes known as rubbing-varnishes should be selected whenever a rubbed finish is desired.[12] Rubbing-varnishes dry hard as they are short-oil varnishes which preferably contain a considerable amount of hard gum, such as congo, manila, kauri, or pontianak. Long-oil varnishes do not rub well, because they make relatively soft films without a high luster. Varnishes which are used for rubbing usually contain from six to twelve gallons of drying-oil to each 100 pounds of resin.

---

[12] See Section 215, "Rubbing-Varnishes," p. 261.

Plenty of time for thoro drying or hardening should be allowed before rubbing is attempted. Very few varnishes dry hard enough to rub under two days, and usually it is preferable to allow from three to six days for drying. If heated drying-rooms are used, the time of drying may be reduced.

Several methods are employed in rubbing varnish: (1) very fine water-proof sandpaper, water, and a wet felt pad; (2) fine sandpaper and rubbing-oil; (3) rough rubbing with lump pumice-stone and water; (4) rubbing with water and pumice-stone powder to produce a dull finish; and (5) rubbing with a special rubbing-oil and pumice-stone powder to make a satin finish. Brush-rubbing, or what might be called scouring, with a very stiff flat brush such as is used for wall brushing with pumice-stone and rubbing-oil, is also sometimes used on coarse work to remove the gloss of varnish.

Every one of the three or more coats applied in producing a rubbed varnish finish must be rubbed in order to produce a satisfactory level and smooth finish of soft luster. On coarse woods the wood-filler largely fills the openings in the cells, and this plugging of the open pores tends to stop capillarity or suction of the many cell openings upon the varnish-coats. Undercoats of shellac-varnish are applied, and should be sandpapered, in order to smooth the surface for later coats of finish, and to improve the adhesion of these films which must firmly attach themselves to the undercoats. Each additional coat of varnish, if sandpapered smooth, tends to add to the level and even effect of the final finish, because all openings below the general level of the surface are finally filled with the varnish while all high spots are cut off each time to the general level of the surface. The first coats of varnish are at present very commonly rubbed by the wet sandpaper method, while the final coats are usually finished by rubbing with pumice-stone.

225. Rubbing with Water-Proof Sandpaper—Very recently excellent water-proof sandpapers having a very fine abrasive attached to hard non-absorbent paper with water-proof glue have appeared on the market.[13] Rubbing with water-proof sandpaper and water is more expensive in cost of materials than is the old method of rubbing with pumice-stone, but much faster, and more satisfactory work can be done between coats of varnish than is possible by the older method.

The sandpaper should be of a fine grit, such as No. 5/0 to No. 8/0, and should be soaked for a moment in water and used over a soft block or wet felt pad. A very dull surface is produced by water-proof sandpaper, tho smoother and more level than that produced by the use of pumice-stone. The rubbing must be done carefully in order to have all the strokes lengthwise of the grain, and to prevent cutting thru the coats of varnish and stain on corners and other exposed places.

226. Rubbing with Oil and Sandpaper.—Varnish films other than the last one are often rubbed between coats with very fine sandpaper and rubbing-oil. This method smoothes the surface satisfactorily, and is helpful in protecting the workmen from the danger of breathing sand-dust which is injurious to health. Rubbing with oil is apt to darken very light woods somewhat. The sandpaper and the surfaces should be cleaned by the use of benzine.

227. Rough Rubbing with Lump Pumice-Stone.—This is an old method for coarse rubbing with water that has been used to some extent by carriage and automobile body finishers. Smooth blocks of pumice-stone are used in place of pads for rubbing.

228. Dull-Finish Rubbing with Pumice-Stone Powder and Water.—An attractive dull finish is produced by rubbing with powdered pumice-stone and a thick felt pad, the abrasive being wet with water. This process is very commonly used in furniture and piano factories to make a perfectly smooth level surface preparatory to the application of a final flowing or polishing coat of varnish. A coarse rubbing is often given first by the use of a medium pumice-stone powder, such as No. ½ or the finer grade No. 0. Felt pads from 1″ to 2″ thick, and of convenient size to hold in the hand, and of coarse or fine texture, are used as rubbing-blocks. Home-made rubbing blocks can be prepared by securing pieces of felt of various grades of fineness and attaching them to wooden blocks of various desired sizes by means of water-proof glue, such as any of the casein glues. The felts should not contain water-soluble dyes which will dissolve into the rubbing-paste and discolor the surfaces.

---

[13] See also Section 9, "Use of Sandpaper," p. 30.

Various procedures are used by wood-finishers in rubbing varnished surfaces. Some finishers prepare a paste in a flat, large, open container, mixing sifted pumice-stone powder with water, and wetting the rubbing-felts in the mixture. The end-grain of large tops or other exposed portions of articles of furniture should usually be rubbed first. There is danger of cutting thru the finish on corners (arrises), by using too much pressure on the pad. Carvings or surfaces of unusual and varied shapes should be rubbed with special rubbing-brushes. Round or curved surfaces can be rubbed with burlap or thin flexible felt pads. Flat surfaces may be rubbed more easily if sponged with water, with a small amount of pumice-stone powder sprinkled evenly over the glossy varnish. On flat surfaces the rubbing must be done very evenly, and straight, or lengthwise of the grain.

One should remember that pumice-stone is really an abrasive, and makes small scratches that are practically invisible when they run lengthwise of the grain, but which show if the rubbing is done across the grain or with circular strokes. The same amount of pressure should be used during the entire rubbing process, and the whole surface should be rubbed evenly. There is a tendency to rub harder in the middle of a long stroke than at the ends, which portions often require additional rubbing with short strokes. The felt pads should be kept wet with the paste and plenty of water, in order to prevent heating or burning. Prolonged rubbing should be avoided or too much of the varnish film may be removed.

The condition of the rubbed varnish should be inspected from time to time by washing and wiping a portion of the surface. This is a check on the finisher's work which will prevent underrubbing or overrubbing of the varnish.

The rubbing-felt should be examined often, and any hardened varnish that has adhered to the felt should be removed. Fragments of varnish on the face of the felt are apt to scratch and damage the surface.

After the coarse rubbing is completed, the surfaces should be washed and wiped clean, then allowed to dry for twelve hours or longer.

Fine pumice-stone powder, FF or FFF, with a fine soft felt is often used in finishing rubbed surfaces. The fine rubbing follows the coarse rubbing after the varnish has been allowed to dry and harden for 12 to 24 hours.

229. Satin-Finish with Rubbing-Oil and Pumice-Stone.—Rubbing with oil is a slower process than rubbing with water, and produces a surface that is different in general effect because a varnish-film rubbed with oil has a higher luster. The oil-rubbed surface is popular at present, and is often called a satin-finish. In appearance it is between the very dull effect produced by rubbing with water and powdered pumice-stone and a highly polished finish, such as is used on a piano.

The satin-finish is produced by scratching very fine lines on a varnished surface by rubbing with oil and very fine pumice-stone of about FF or FFF grade. The finisher should make a series of very fine straight lines that are parallel to each other by careful rubbing lengthwise of the surface. The fine lengthwise scratches on wood do not show, if made carefully, but any cross, oblique, or circular scratches can be seen, and will spoil the finish. Water-stained finishes are particularly sensitive to scratching by careless rubbing. The proper oil for use in rubbing is a neutral mineral oil or a paraffin-oil, rather than linseed-oil. Prepared rubbing-oils are sold on the market by most of the wood-finishing supply-houses. Some expert rubbers use a crude-petroleum oil for rubbing, while still others prefer kerosene because very fast rubbing can be done with it.

The pumice-stone should be thoroly cleaned from the surface with naphtha, benzine, or some other cheap thinner and a rag after the work is finished. For inspection, small portions of each surface should be cleaned from time to time. This can be done by wiping or cleaning with the palm of the hand or with a rag.

The oil-rubbing method should not be used between the various coats of varnish, because the later coats will not adhere well to such a finish. Oil-rubbing is for the final coat only and often precedes polishing.

In factories machine-rubbing has, to some extent, taken the place of hand-rubbing. The machines are operated by small electric motors which cause two oscillating felt-covered pads about 4″ or 5″ square to do the rubbing.

POLISHING PROCESSES

The brilliant polish which is often placed on high-grade pianos is not often used in the finishing of furniture and the woodwork of houses. The satin-finish which is produced by rubbing a coat of varnish with a mineral rubbing-oil is, however, sometimes polished with rottenstone, and is in this manner given much additional luster. A dull surface that has been produced by rubbing with water and fine pumice-stone powder may also be polished to a considerable extent.

Piano-polishing is usually done on a final coat of polishing-varnish, a short-oil varnish that dries very hard and has a high luster.[14] Polishing-varnish when used should be applied as a last coat over surfaces that have been well filled, if the wood is porous. As a foundation for the polishing-varnish there should be several undercoats of rubbing-varnish, properly sandpapered or rubbed with water and pumice-stone between coats. A person should not attempt to polish a varnished object unless perfectly level surfaces have been prepared with several coats of varnish.

Polishing a varnished surface with rottenstone after it has been rubbed with pumice-stone removes the fine scratches that were made on the surface by the pumice-stone, and produces a very level smooth surface, with a high luster that varies somewhat with the composition of the film of varnish on the surface.

Three methods of polishing varnished surfaces are used by wood-finishers: (1) polishing with rottenstone and water; (2) polishing with rottenstone and oil; and (3) "spiriting off" or French polishing with alcohol.

A much higher luster can be produced by any of the methods if a polishing-varnish is used for the last coat. Polishing may be done, however, with either oil or water, over rubbing-varnish or polishing-varnish. Long-oil varnishes are usually too soft to receive a high polish.

230. Polishing with Rottenstone and Water. — The method of putting a quick but rather low polish on the rubbing-varnish itself, after fine rubbing with pumice-stone and water and a redrying of the surface of at least twelve hours, is very commonly used on ordinary furniture and the woodwork of houses. If the preceding rubbing with pumice-stone has been done with water, the polishing can also easily be done with water and rottenstone. Carefully sifted rottenstone does not scratch, but it may contain grit that makes fine lines. In order to avoid scratching it is wise to rub lengthwise of the grain of wood for the final polishing when water is used with rottenstone for polishing. Some polishers rub across the grain to remove the pumice-stone scratches when the polishing process is started with rottenstone. Other skilled finishers use a circular motion in polishing. The final polishing, however, is usually done by rubbing carefully lengthwise of the grain. A very fine piece of felt of convenient size to hold in the hand and about ¼″ thick makes an excellent polishing-pad. The finisher's hand is often used for the final polishing.

---

[14] See Section 214, "Polishing-Varnishes," p. 260.

231. Polishing with Rottenstone and Oil.—The oil method with rottenstone is preferable for finishing surfaces that have been rubbed with pumice-stone and oil. A thin, fine, soft piece of felt is generally employed as a pad in the oil-polishing process. A pad of cotton-waste dampened with water then with oil-polish is often used. Rottenstone in the form of a brick may be rubbed on the pads, or very fine sifted powder of the same material may be mixed with the polishing-oil itself or sprinkled over the surface which is to be polished. There are many rubbing-oils, polishes, cleaners, and furniture-renovators on the market. Every polisher is apt to have a favorite formula which he has learned how to use. Numerous liquid furniture-polishes are for sale, ready for use. Some of these polishes are very satisfactory tho rather expensive.

The oil-polishing liquids vary somewhat in ingredients, but usually they are made up from mixtures of oil, such as raw linseed, boiled linseed, or golden oil, together with denatured or wood alcohol, vinegar or acetic acid, and antimony trichloride ($SbCl_3$), called butter of antimony. The chief purpose of using acetic acid or vinegar in a polishing-oil is because of its strong cleansing action. If the work is newly varnished, or if an old surface has been washed thoroly with soap and water, there is little or no necessity for acetic acid in a polishing-oil, tho its activity on the surface possibly makes the polishing process more rapid.

Lemon-oil, made from the rind of lemons, is thought to possess unusual virtues by some polishers who use it in a mixture of 2 ounces to the gallon of neutral polishing-oil. Olive-oil, also called sweet oil, is thought to be the best polishing oil by other finishers. Linseed-oil is often used, especially in polishes for old furniture. Its drying properties are such that there is danger of spontaneous combustion if rags saturated with it are left in masses where they can heat and catch fire. Felt polishing-pads containing linseed-oil from a furniture polishing-liquid should be cleaned with benzine or some other volatile thinner after they are no longer needed for the day. Unless all linseed-oil is removed by cleaning, or the pad is kept wet in a thinning fluid, the pad may become heated thru oxidation and catch fire. Cotton-waste polishing-pads that have been used with oil polishing-liquids should be placed in a fire-proof waste-can and removed from the building daily.

232. Polishing-Oil Formulas.—Some polishing-oil formulas recommended by experienced wood-finishers are as follows:

Formula No. 1.

1¼ oz. oil of cedar,
½ pint pure turpentine,
½ pint paraffin oil,
¼ to ¾ oz. oil of citronella,
2 oz. sifted rottenstone powder.

Shake the mixture thoroly, and allow a few days for assimilation.

Formula No. 2.

1 pint raw linseed-oil.
1 pint light golden oil,
1 pint 5 oz. distilled water or rain-water.
Mix the above, and add
¼ pint acetic acid,
1 oz. antimony trichloride ($SbCl_3$) (butter of antimony),
⅛ pint denatured or wood alcohol,
3 oz. sifted rottenstone powder.

Formula No. 3.

½ pint olive-oil,
½ pint denatured alcohol,
2 oz. sifted rottenstone powder.

In repolishing old varnished surfaces it is desirable to include acetic acid in the formula, because it cleans the old varnish and hastens the action of the polish. The following formulas are well adapted for this purpose:

Formula No. 4.

½ pint turpentine,
½ pint boiled linseed-oil,
½ pint strong vinegar,
1 to 3 ounces of sifted rottenstone may be added, if it is desired to polish rather than clean and renovate.

Formula No. 5.

1 quart paraffin-oil,
1 quart denatured alcohol,
1 pint to 1 quart strong vinegar,
3 to 6 ounces of sifted rottenstone may be added if desired.

233. Spiriting-Off or French Polishing with Alcohol.—An oil-polished surface is sometimes given a very high luster by "spiriting-off" the varnish with denatured alcohol. The method is expensive, and is not often used except on high-grade furniture that requires a very brilliant luster.

After a satisfactory polish has been secured on a polishing- or finishing-varnish by use of rottenstone and an oil composed of ¼ to ½ oz. of lemon oil to a pint of neutral oil, the surface should be thoroly cleaned. The human hand, if the skin is in good condition and without callouses, makes the best polishing-pad. The hand should be wet with polishing-oil at the start of the process, and nearly dry at the finish. After rubbing carefully with the lemon-oil polish, using a circular motion, the surface should be cleaned in order to remove any particles of rottenstone. The surface may be wiped off with a lemon-oil polish which contains no rottenstone.

"Spiriting-off" may be done with a soft wad of cloth which has been dampened but is not wet with denatured alcohol. The excess of alcohol should be wrung out of the polishing-rag. Great care must be taken in "spiriting-off" the surface, or the alcohol will burn thru the varnish and spoil the finish. The polishing-pad should be kept moving in circles, and not allowed to come to a rest for a moment on the surface. Some finishers dampen the rubbing-cloth with water, then wring it dry. They next dampen the rag with alcohol slightly and wring it nearly dry in order to reduce the strength of the alcohol by putting it on a moist rag instead of a dry one. The quick wiping in the "spiriting-off" process cleans the polishing-oil from the surface and leaves a clean brilliant luster.

234. Varnish-Removers.—Certain liquids when applied to varnished surfaces possess strong enough solvent action to soften the dry and hard films in such a manner that they can be scraped off. Some of the solvent liquids commonly used in varnish-removers are denatured and wood alcohol, benzol, acetone, amyl acetate, butyl acetate, fusel-oil, strong caustic soda solution with water and also ammonia and other alkalies.

Many varnish-removers contain paraffin in various amounts sometimes in quantities sufficient to make the remover appear like a thin paste. The wax is used to keep the volatile liquids from evaporating too rapidly from the varnish-coatings. Such thick paraffin removers are especially useful on vertical and oblique surfaces. Every trace of wax, such as paraffin, must be removed before the surface can be refinished because shellac and varnish will not adhere properly to material that has wax on it. Benzine, gasoline, or turpentine can be added to dissolve and remove the paraffin.

Acetone is often an important ingredient in the better grades of varnish-removers, while cheaper solvents, such as alcohol and benzol, are the chief ingredients in inexpensive removers.

Many formulas for varnish-removers contain liquids that will burn the skin, and all such mixtures must be applied with rubber gloves, or with care to keep the liquid away from the hands entirely.

Varnish-removers that contain alkalies are liable to darken the wood to some extent. The amount of darkening is not usually serious or very objectionable except on very light-colored woods.

235. Formulas for Paint and Varnish Removers.

Formula No. 1.

1 qt. denatured alcohol (high proof—188° or 190°),
1 qt. benzol (90 per cent quality),
¼ lb. paraffin-wax.

The wax should be melted first, and poured into the benzol after taking both of these *away from the fire.* Then, while stirring, pour the benzol into the alcohol.

Formula No. 2.

½ gal. benzol (90 per cent grade),
1 qt. acetone
1 qt. wood alcohol,
½ lb. paraffin-wax.

Formula No. 3.

1 qt. strong ammonia (26° or 28°),
1 pt. turpentine.

Mix the ingredients together by shaking thoroly in a bottle.

This formula is useful for the removal of paint rather than varnish, because the irritating ammonia should not be used indoors, and it tends to darken the wood somewhat. The discoloration can be removed to some extent by sandpapering the surface with No. ½ sandpaper.

Many prepared varnish-removers are for sale on the market, and these preparations are generally more satisfactory for use in schools than are those which are home-made.

236. Cleaning Varnish-Brushes.—The various solvents used as thinners in varnish can be used in most cases as cleaners for varnish-brushes. In school shops, turpentine is often employed as a cleaning fluid. Varnish-brushes that have been neglected until gum partly hardens about the ferrule can be cleaned more satisfactorily by the use of amyl acetate, or butyl acetate, which is cheaper tho not quite so good a solvent.

Many liquid varnish-removers are also satisfactory for use as brush-cleaners. Varnish-removers containing strong alkalies damage the bristles of the brushes, and must be avoided or used with great caution. Varnish-removers should be cleaned out of brushes by a final washing in turpentine, especially if the brush is to be put back into varnish in a wet condition.

REFERENCES—CHAPTER XIV

OIL OR OLEORESINOUS VARNISHES (*Continued*)

TYPES—PROPERTIES—APPLICATION—RUBBING—REMOVING

G. B. Heckel, *A Varnish Catechism* (Published by American Paint and Varnish Manufacturers' Association, Philadelphia, Pennsylvania).

Harry R. Jeffrey, *Wood-Finishing,* pp. 53-74.

A. Ashmun Kelly, *The Expert Wood-Finisher,* pp. 144-151, 179-203, 237, 241, 252, 259.

William S. Loundes, *Painting and Wood-Finishing* (International Textbook Co.), pp. 88-98.

R. A. McGee and A. G. Brown, *Instruction Units in Wood-Finishing,* pp. 29-35, 40-47.

A. B. Pattou and C. L. Vaughn, *Furniture-Finishing, Decoration, and Patching,* pp. 199-232, 389, 531.

Alvah Horton Sabin, *House-Painting,* "Varnishing," pp. 65-74.

Walter K. Schmidt, *Problems of the Finishing-Room,* pp. 251-288, 403.

S. W. Stratton, *Paint and Varnish,* Bureau of Standards, United States Department of Commerce, Circular No. 69.

F. N. Vanderwalker, *Wood-Finishing, Plain and Decorative,* pp. 153-230.

CHAPTER XV

LACQUERS—HISTORY, USES, AND COMPOSITION

237. Brief History of Lacquers.—Few persons comprehend just what lacquer is, because the term has been used for at least three finishing-materials of quite different composition. Sometimes the word is used in referring to certain varnish-like materials used in the celebrated and much admired lustrous finishes that for many years have been coated over wood by the artistic workmen of Japan and China, and to a lesser extent of Ceylon, India, and Burma.

During many centuries, at least as far back as 500 to 600 B. C. according to some authorities, Chinese and Japan workmen have probably used these remarkable and beautiful finishes which unquestionably were superior to anything else of their kind in any part of the world. These oriental peoples discovered that a liquid exudation could be taken in spring and summer from a certain lac tree (*Rhus vernicifera*) by making cuts or scarifications, and that this fluid became thick and creamy, and later on changed, becoming darker in color. Several millions of pounds of this raw material usually pass annually thru the Chinese city of Hankow, the greater part being shipped to Japan where it is known as "*Ki-urushi.*" At first when the sappy exudation comes from the trees it is of a gray-brown color and is somewhat viscous and sticky, or mucilaginous in consistency; but finally, after exposure to the air, it turns practically black, being coated over with a rather tough and thick covering.

Oriental lacquers dry by oxidation, and are like oil-varnishes in that peculiarity, being entirely dissimilar from nitrocellulose lacquers which dry by evaporation. Tung-oil or perilla-oil is sometimes mixed with the natural lacquers from the trees, but these drying-oils are not necessary and are regarded as adulterants. More body is added to the Chinese lacquers, according to one writer, by the addition of 30 grams of Roman vitriol and 40 grams of pig's gall to each kilogram of lacquer.[1] Sabin, in his interesting and detailed description of Chinese and Japanese lacquers, also mentions the use of Roman vitriol and hog's gall in compounding Chinese lacquers.[2]

The Japanese make their lacquer from the same gum or resinous material that is used by the Chinese. In Japan the lacquer is thinned with camphor which is thought to be the only proper thinner for making it more fluid. Some authorities think that the Japanese lacquer films or coatings are more durable than finishes made from any of our best resins. Their durability is undoubtedly greater because they are nearly always applied over a wood of exceptional hardness, called *teak*, which shrinks and warps very little, and does not often check or crack. The lacquering fluid originally is nearly clear, but films after being spread and exposed to the air at first turn to a reddish color and finally change to a rich black. The hardness of such films increases with time. Finishes made from them have a brilliant and permanent luster which is unchangeable with weather conditions. The oriental lacquers are also said to be impervious to varnish-removers and other solvents.

An interesting peculiarity of Japanese lacquer made from the Rhus tree is that it hardens properly only in a moist atmosphere. If exposed to heat and sunlight, it remains in a tacky condition instead of drying properly. Oxidation takes place during the drying of a film, and sometimes as much as 5¾ per cent of weight may be added during the drying process at ordinary temperature.

The black lacquer or "*thitsi*" of Burma is made in a manner somewhat similar to that used in compounding the famous Japanese lacquer; but in this case the gumlike material comes from a different tree, the *Melanorrhea usitata.* The black lacquer of Burma is slower in drying than the Japanese lacquer.

---

[1] See Ch. Coffignier, *Colors and Varnishes*, p. 242.

[2] See A. H. Sabin, *Technology of Paint and Varnish* (third edition), p. 210.

The lacquer commonly used in Europe and the United States before the World War was simply a spirit-varnish. It was often largely shellac, which takes its name from lac or "lakh." In the dictionaries or text-books written a few years ago, lacquer is said to be a shellac or spirit-varnish. These so-called lacquers were made in large quantities in both clear and colored solutions and were used sometimes on wood, but much more often on metals, such as brass especially, to prevent tarnishing and to give a soft pleasing luster.

Other spirit-soluble gums, such as sandarac and elemi, were often added to the mixture of shellac and alcohol in compounding the lacquer. Spirit-soluble vegetable dyes were formerly used in these spirit-varnish lacquers, but coal-tar dyes gradually replaced them as dyestuffs in colored lacquers. Lacquers of this type were very thin, and had little body; consequently a very large number of applications was necessary. These early lacquers were quite satisfactory and durable, and could be made to adhere more firmly to metalwork when baked on at temperatures under 115° C., which is the melting-point of shellac. Lower temperatures than the melting-point will soften and fuse the shellac-gum very firmly to the metal.

The oriental lacquers as well as the spirit-varnish or shellac lacquers, just described, are really varnishes, and not lacquers, in the sense that the word is now used in the United States. The metal trades for a number of years have been trying a new type of lacquer for a very tough, hard finish. This finishing-material was manufactured in the form of clear lacquer, and also in pigmented compounds, sometimes called lacquer-enamels. It was necessary to make this material very thin in order to apply it at all, which resulted in very thin films and many coats. It was not satisfactory in the early forms for finishing wood, because it did not adhere properly and soon peeled or scaled off.

The body material or solid content of these early metal-lacquers consisted largely of pyroxylin, or high-viscosity nitrocellulose of a non-explosive form. When large amounts of nitrocellulose were contained in the lacquer it became viscous and heavy and could not be spread evenly over a surface; consequently much reducer or thinner was added, and the film was so thin that it was often necessary to apply as many as 15 to 20 coats.

Since the World War, chemists have discovered that various varnish-resins can be dissolved in solvents and incorporated in low-viscosity nitrocellulose mixtures, and this discovery brought to the market a new type of finishing-material for automobiles and furniture, especially, which we now call lacquer. Varnish-resins add greatly to the body or thickness of the film. At the present time in the United States the term lacquer-finish, when used in connection with automobiles and furniture, usually refers to this new type of finish made from nitrocellulose and varnish-gums with various other substances in a highly complex mixture. These new nitrocellulose lacquers which include resins in their composition are somewhat similar to varnish in the thickness of the films that can be obtained from them. Relatively few coats of our latest nitrocellulose-resin type of lacquer are required, on account of the large amount of solid material contained in the mixture and the thickness of each layer or film after it is dried on a surface.

Recently another type of quick-drying finish called "varnish-lacquer" is said to have been produced.[3] This lacquer dries more slowly than the ordinary nitrocellulose compounds previously used, but contains a specially-treated varnish containing vegetable oils which act as ultra-violet-ray filters for sunlight, and add a plasticity similar to that of oil-varnishes. Little is known about this new lacquer, but it is reported to show up well in tests in outdoor trials of clear varnish-lacquer on automobiles over colored lacquer.

---

[3] See Paul S. Kennedy, "Problems for Research in Lacquer and Varnish," Furniture Manufacturer Magazine, Vol. XXXIV, No. 6, p. 62.

The term *lacquer* has gradually come to refer to a very quick-drying varnish-like finish which dries to great hardness. The term itself does not positively indicate any special composition. In the United States the word lacquer generally refers to nitrocellulose compounds, but this may change if some other more suitable substance finally replaces this material as an ingredient in quick-drying finishes.

238. Uses for Lacquers.—Almost all of the large paint and varnish manufacturers in the United States are now making lacquers, which in some cases are being unwisely advertised as suitable for nearly all purposes. In the hands of a skilled finisher they produce satisfactory effects; but when a novice attempts to spread them with a brush over newly varnished surfaces, there is sure to be trouble because the solvents in the lacquer are similar to those contained in some of the paint-and-varnish removers, and the newly applied coating reacts with the old, resulting in a spoiled finish. If a varnished or enameled surface is old, hard, and well preserved, a lacquer finish may adhere satisfactorily soon after it is applied; but, later on, checking is apt to occur. Lacquer finishes have certain limitations, and cannot be used over other finishes indiscriminately with assurance of success.

Lacquer-finishes are gradually growing in popularity, and when used properly by one who understands them and their limitations they are attractive and durable and possess many good qualities. Lacquer-enamels which are pigmented lacquers are successful and popular finishes for automobiles. Lacquers of various kinds are used extensively on metalwork, particularly building-hardware, electric-light fixtures, metal spinning and stamping objects, and often for toys, art-work, and even jewelry. Lacquers are also satisfactorily used on high-grade furniture. Pigmented lacquers are used on electric-light fixtures, novelties, and machinery, and also almost universally on the highest priced automobiles.

239. Composition of Nitrocellulose Lacquers.—Clear or transparent lacquers contain five types of ingredients, while pigmented lacquers, which are often called lacquer-enamels, contain six types, the names of which are as follows: (1) nitrocellulose or pyroxylin, (2) varnish resins, (3) solvents, (4) plasticizers and softeners, and (5) diluents or thinners. Lacquer-enamels must give obscuration or hiding power, and to give this opacity various kinds of pigments and coloring-matter are added to the lacquer. Pigments and coloring-matter may therefore be considered as the sixth type of ingredient found in lacquers.

240. Nitrocellulose, Soluble Cotton, or Pyroxylin.—The distinctive ingredient in a modern lacquer, that makes it quite different in behavior from other varnish-like materials, is given various names, such as nitrocellulose, cellulose nitrate, soluble cotton, and pyroxylin. The words nitrocellulose and nitrocotton mean that the substance is made of cellulose or cotton that has been nitrated. Cotton is one of the purest forms of cellulose fibers, and is the chief source of raw material from which nitrocellulose is manufactured. Long-fibered cotton which is valuable for making cotton-cloth is usually too expensive for nitrating; therefore, the short-fibered material, called "cotton linters," is generally used.

In the factories the cotton-gin removes the long-fibered cotton from the linters, hull fibers, dirt, and other impurities. The linters are separated from the waste material by boiling, chemical treatment, bleaching, washing, and drying, and are then nitrated thru treatment with a mixture of nitric and sulphuric acids. It is said that the particular function of the sulphuric acid is to remove the moisture from the cotton fibers during the nitrating process.

The amount of nitrogen given to the cotton is very carefully controlled, and depends upon the use for which the nitrocellulose is intended. The nitrogen content of nitrocellulose used in lacquer varies from 11.5 to 12.4 per cent, with a viscosity of a half-second up to about 80 seconds.[4] Nitrocellulose having between 12.5 to 13.5 per cent of nitrogen is called gun-cotton, being used in the manufacture of smokeless powder and various explosives.

Nitrocellulose for use in making lacquer is made wet with denatured alcohol, in order to remove traces of water, and then dried out to a 30 per cent alcohol content mixture, which is not explosive tho inflammable. The gun-cotton type of nitrocellulose, having between 12.5 to 13.5 per cent by weight of nitrogen, is very explosive when dry, and is soluble only in acetone, while the nitrocelluloses which contain a lower amount of nitrogen are easily soluble in a mixture of anhydrous ethyl alcohol, anhydrous ethyl acetate, and other well-known solvents.

The viscosity of the early types of nitrocellulose used in making lacquers for metal was relatively high, and the amount of solvents and thinners were great in proportion, the result being a very thin film when the mixture was applied. The lacquers of the present day usually contain a nitrocellulose of rather low viscosity (½ second), and certain resins which, when combined, produce a film that is much like a varnish in body or solid matter.

241. Varnish-Resins Used in Lacquers.—The presence of resins in the mixture is the distinctive and probably the most important feature of modern lacquers, especially those made for wood. The latter type usually contains a higher proportion of resins to nitrocellulose than is ordinarily found in lacquers for automobiles. Wood-lacquers are, consequently, more like varnishes on account of their greater solid content and the thicker films that can be spread with them. Lacquer-finishes containing resins can be rubbed like coats of oil-varnish, because they have gums in their composition. Resins are valuable in a lacquer for another reason besides increasing the solid content, namely, because they increase the power of the film to adhere to the surfaces to which they have been applied. The resins selected for lacquers are generally cheaper than nitrocellulose, and this is also an important factor, because it reduces the cost of the mixture per gallon.

---

[4] See D. B. Keyes, "Solvents and Automobile Lacquers," Industrial and Engineering Chemistry, Vol. No. XVII, No. 6, June, 1925, p. 559.

Some of the resins, such as mastic and sandarac, have very poor adhesive powers, and produce soft films when used in a nitrocellulose-lacquer mixture; therefore, they are unsatisfactory. Other well-known varnish-resins seem to give increased adhesive properties. Resins that increase adhesive qualities of lacquer are given by D. B. Keyes as follows: shellac, rosin, thus, elemi, pontianak, congo, and zanzibar.[5] The selection of resins for a lacquer mixture depends upon other properties, among them being solubility in the same solvents that have been found best for dissolving the nitrocellulose itself.

Anhydrous ethyl or grain alcohol will dissolve many kinds of varnish-resins, and the solutions will blend well with nitrocellulose solutions of the same solvent. Another good solvent for nitrocellulose, called anhydrous ethyl acetate, is a good solvent also for such gums as rosin, thus, ester-gums, and cumar. If anhydrous ethyl alcohol, in quantities varying from 5 to 30 per cent, is added to the solution of anhydrous ethyl acetate, the mixture will dissolve such gums as elemi, dammar, and shellac. Other resins such as sandarac, kauri, pontianak, and manila gum, are soluble in part; while such hard copals as congo and zanzibar are not soluble in the mixture of the two solvents, but are at least partly soluble in the anhydrous ethyl alcohol alone.

The resins commonly used in lacquers are synthetic or chemically prepared ester-gum (a chemical combination of rosin with glycerine), a resin from the rosin group, dammar, and shellac. A certain amount of waxy residue must be removed from alcoholic solutions of dammar and shellac before these resins in their solvents can be blended into the lacquer mixture.[6] Sometimes a lacquer of heavy body is desired, and such gums as dammar, kauri, shellac, and synthetic ester-gums are used in amounts which nearly equal the quantity of nitrocellulose itself. Automobile lacquers, however, often contain only one-half the quantity by weight of resin compared with nitrocellulose.

---

[5] See D. B. Keyes, "Solvents for Automobile Lacquers," Industrial and Engineering Chemistry, Vol. XVII, No. 6, June, 1925, p. 559.

The density and strength of lacquer-films vary to some extent with the resins or resin incorporated in the lacquer mixture. Such varnish-resins as kauri and congo are considered to be excellent for supplying the desirable qualities of hardness and toughness to the film. Both of these gums are, however, less easily soluble in the solvents which are used with nitrocellulose. Unfortunately the best grades of kauri resins are usually high-priced. Dammar and other medium soft-resins give toughness to lacquer films which remain rather soft. Hardness and brittleness, the latter being an undesirable quality, are imparted by soft resins and especially by rosin.

With these characteristics in mind, many manufacturers use a combination of several resins. The non-synthetic gums often used in combination are generally selected from the following list: dammar, shellac, kauri, spirit-soluble manila, and congo. Dammar is the non-synthetic gum most commonly used at present, altho for outside service it is seldom incorporated in large amounts in high-grade lacquers. Bleached shellac, altho high-priced, is sometimes employed as a lacquer-resin because it is said to add hardness and adhesion and produces a fine gloss. Several synthetic gums are manufactured for lacquer-making, especially cumar, amberol, backesite, and ester-gum.

From all information which is available, it seems evident that ester-gum is employed in manufacturing lacquers much more extensively than any other single resin.[7] It should be noted, however, that ester-gum when used alone produces a chalky lacquer that is somewhat spongy. It is usual, therefore, to add a small amount at least of dammar solution which has been dewaxed, because such a mixture of gums produces a more satisfactory film. Some other resin may be substituted for the dammar, however. Various grades of rosin are little used except in cheap lacquer.

---

[6] See Paul M. Mowen, "Gums Suitable for Pyroxylin Lacquers," Paint Oil and Chemical Review, Vol. 85, No. 19 (May 10th, 1928), pp. 10, 11.

[7] See Winfield G. Scott, *Formulas and Processes for Manufacturing Paints, Oils, and Varnishes,* Appendix, "Nictrocellulose Lacquers," pp. 211-215.

242. Solvents for Nitrocellulose and Resins.—The best solvents for lacquers consist of mixtures of various liquids because of the fact that no single fluid is known which is capable of dissolving compounds of nitrocellulose and varnish-gums and holding them in proper condition while they are being applied as films or coatings. The selection of proper solvents for use in manufacturing lacquer seems to be of fundamental importance, for the reason that success or failure is thought to depend more on the solvents than on the selection of any particular varnish-resin or other detail of composition. From the user's standpoint it is very desirable that no objectionable odor such as that given off by fusel-oil shall come from the solvents chosen. On account of the fundamental differences in the methods of drying of lacquer and varnish—lacquer drying by evaporation, and varnish by both evaporation and oxidation—the solvent, or rather the mixture of solvents with plasticizers and softeners, must dry slowly enough to enable the lacquer to be applied successfully.

Keeping qualities and stability of chemical composition while the lacquer is in cans in the liquid state are also necessary; therefore, the solvents must not slowly decompose. The price of lacquers would be practically prohibitive were it not for the fact that solvents are selected that can be used in the same mixture with cheap hydrocarbon diluents, such as benzene, toluene, and xylene, which serve the double purpose of improving the flowing or leveling qualities of lacquer during its application, and reducing its cost per gallon when used as thinners.

An understandable and simple classification of lacquer-solvents seems to be difficult to make. Various methods have been suggested. A physical classification resulting from grouping the different solvents and diluents or thinners according to their boiling-points has recently been suggested, and seems to be more comprehensible than any chemical classification which has yet been offered.[8] Hydrocarbons, such as benzene, toluene, and xylene, are often listed among lacquer-solvents because they are solvents for many resins, especially those used in lacquers. These hydrocarbons are not solvents of nitrocellulose, and cannot be used in large amounts without a tendency to gel or coagulate the clear solution of nitrocellulose, thus producing a cloudy mixture.

The term solvent in the lacquer industry is now often used in a rather restricted and special sense. Liquids that have the power within themselves to dissolve nitro-cotton or nitrocellulose are frequently called solvents or active solvents. Among the most used of the active lacquer-solvents are certain organic esters, such as amyl acetate, butyl acetate, ethyl acetate, and butyl propionate. From the various alcohols, such as methyl, ethyl, amyl, butyl, and propyl, a number of valuable esters are now manufactured, some in large quantities and at a very moderate price, particularly butyl acetate. All of the acids are said to be nitrocellulose solvents. The acetates furnish several excellent solvents, while others are usually found among the formates, propionates, lactates, carbonates, oxalates, and ketones, the last named furnishing acetone.

In the lacquer industry the term nonsolvents is usually given to those liquids used as menstrua for varnish-resins, and that become solvents for nitrocellulose by the addition of some other liquid. These so-called non-solvents or inactive solvents, such as amyl alcohol, butyl alcohol, ethyl alcohol, and even methyl alcohol to a rather limited extent, can usually be made into active solvents for nitrocellulose in various degrees of strength by the addition of an active solvent. The chief function of lacquer nonsolvent liquids is to dissolve the varnish-gums or resins which are used in various proportions to give adherence, body, and luster to the lacquer films. Nonsolvents are cheaper, in general, than true nitrocellulose solvents; consequently they help in reducing the cost of the materials used.

---

[8] See D. B. Keyes, "Solvents and Automobile Lacquers," Industrial and Engineering Chemistry, Vol. XVII, No. 6, pp. 560-564.

Some writers classify the active nitrocellulose solvents and nonsolvents or gum-solvents in one group, calling all of them solvents; while other authorities place the inactive nonsolvent liquids in a group with the hydrocarbon diluents, which have somewhat similar functions and tend to blend the various mixtures and reduce the cost of the liquids.

The physical classification of solvents, inactive or nonsolvents, and diluents depending upon boiling-points can be outlined as follows:

1. *Low boilers*—distillates which boil and vaporize at temperatures below about 100°.

	Boiling-Point in Degrees Centigrade
Ethyl alcohol (anhydrous)	78.3 to 78.4
Ethyl acetate (anhydrous)	77
Methyl acetate	56 to 57
Ethyl propionate	98 to 102
Monoethyl ether of ethelene glycol	98 to 99
Isoprophyl alcohol	82
Acetone	57
Benzene (a hydrocarbon diluent)	80

2. *Medium boilers*—distillates which boil and vaporize at about 125°.

	Boiling-Point in Degrees Centigrade
Diethyl carbonate	125 to 126
Amyl acetate	138 to 142
Amyl alcohol	126 to 132
Butyl acetate	125
Butyl alcohol	117
Toluene (a hydrocarbon diluent)	111

3. *High boilers*—distillates which boil and vaporize at about 150° to 200°.

	Boiling-Point in Degrees Centigrade
Ethyl lactate	152 to 155
Ethyl glycolate	160
Diacetone alcohol	164
Diethyl oxalate	186
Benzyl alcohol	205
Ethyl Benzoate	212
Xylene (a hydrocarbon diluent)	143

Some of the best solvents for lacquers are combinations of solvents, such as ethyl ether and ethyl alcohol. Another excellent mixture for solvents is a combination of ethyl alcohol and ethyl acetate. Various important binary combinations may be used as lacquer-solvents, according to Dr. Keyes, as follows: "ester-alcohol, ether-alcohol, ketone-alcohol, ketone-ester, ketone-ether, and ester-ether."[9]

A discussion of the various good and bad properties of these solvents would not be profitable in a book of this type which is not intended as a guide to manufacturers of lacquer. Some of the most common solvents, however, may be referred to briefly.

Anhydrous ethyl alcohol (C_2H_5 OH), which is a pure alcohol that does not contain water, is probably the best of all of the inactive lacquer-solvents, because, when activated with a small per cent of ethyl acetate, it easily dissolves nitrocellulose and also many of the varnish-gums that are likely to be selected for use in lacquers. Ethyl alcohol in the anhydrous form is a much better solvent for nitrocellulose and spirit-soluble resin-gums than is the ordinary 95 per cent by volume ethyl or grain alcohol, and it also blends mixtures of the two substances, which are usually dissolved separately, much better than does the less pure alcohol.

Anhydrous alcohol has another advantage; because, when it is used, a larger amount of cheap hydrocarbon diluents such as benzene, toluene, or xylene, can be added to the lacquer. Ethyl alcohol, however, has great water-absorptive powers, and is apt to take moisture from the air and hold it in the film during the evaporation process. The lowering of the activity of the alcohol solvent permits the precipitation of some of the solid components of the lacquer, and this change in solubility causes a discoloration of a film which is known as *"blushing."*

---

[9] D. B. Keyes, "Two-Type Lacquer-Solvents," Industrial and Engineering Chemistry, Vol. XVII, No. 11, December, 1925, p. 1120.

Ethyl alcohol, even when denatured with active solvents for varnish-gums and nitrocellulose, should be used with caution and only in limited amounts. It is commonly used by manufacturers for wetting the nitrocellulose, thus making it safer for handling and shipping. The wood-finisher should not thin lacquer with ethyl alcohol unless it is properly mixed with the necessary active solvents and diluents.

Ethyl alcohol is often called a nonsolvent because it will not dissolve nitrocellulose unless activated by having some other liquid introduced into it which has the needed solvent activity.

Anhydrous ethyl acetate ($CH_3COO_2H_5$), an organic ester, which is in a purer form than the 85 per cent ethyl acetate of commerce, is really an active solvent for nitrocellulose, while ethyl alcohol is not; but the former is not so efficient in dissolving varnish-resins as is the latter substance. A mixture of the two solvents—anhydrous ethyl alcohol and anhydrous ethyl acetate—seems to produce an excellent fluid for dissolving the solid content or body materials that are required in lacquer. The two solvents just named are commonly used in lacquer, and are known by some as low-boiling solvents.

Monoethyl ether of ethylene glycol, sometimes called *Cello Solve,* is a low-boiling solvent which boils at 98°-99° C.[10] It has proved to be a superior solvent for nitrocellulose, dissolves gums such as shellac, kauri, sandarac, mastic, elemi, and rosin "E," and is excellent in a lacquer because it enables the mixture to stand a greater dilution with nonsolvent hydrocarbons, such as toluene, than is possible with most other solvents having similar boiling-points. Lacquers containing this solvent possess good power for covering and hiding, and show less tendency to cut thru the undercoats with a brush after several coats have been applied.

---

[10] See J. G. Davidson, "The Glycol Ethers and Their Use in the Lacquer Industry," Industrial Engineering Chemistry, Vol. 18, No. 7, pp. 671-675.

Monoethyl ether of ethylene glycol can also be diluted with gasoline or water. Its ability to absorb water is of advantage to a lacquer because it prevents ''blushing'' or cloudy effects in drying out. Blushing is the result of precipitation, either of gums or nitrocellulose, when the solvents do not keep them in a satisfactory liquid form. The glycol ethers do not have an unpleasant odor, and are useful in lacquers that are sprayed. This lack of a disagreeable odor is valuable in the finishing-room, and especially in rooms in which the woodwork is being refinished, for they can be used again shortly as the lacquer usually dries practically hard within an hour.

The glycol ethers are valuable solvents for use in both spraying and brushing lacquers. One authority reports that it is possible to make brushing-lacquers that will spread as well with a brush as paint-enamel, if one of the glycol ethers, such as monoethyl ether of ethylene glycol, is used in proper amounts as a solvent.[11]

Diethyl carbonate is an excellent medium-boiling nitrocellulose solvent which improves the flowing qualities of lacquer and has a pleasant odor. The odor of many of the other medium boilers sometimes used is very disagreeable, and their use in spraying-lacquers practically necessitates the installation of ventilated hoods. Diethyl carbonate is a stable compound of synthetic production which is a good solvent for nitrocellulose, and also for many of the resins used in lacquers, such as mastic, rosin, ester gums, thus, and cumar. Some gums, including kauri, sandarac, manila, and elemi, require the addition of at least 5 to 10 per cent of anhydrous ethyl alcohol to diethyl-carbonate solutions before they will dissolve completely. As much as 40 per cent of the two solvents just mentioned must be alcohol in order to dissolve shellac-gum.

---

[11] Ibid., p. 674.

Congo-resins and other hard copals cannot be dissolved in these solvents. Dammar-gum leaves a waxy portion which will not dissolve. Unless a small amount of alcohol is used in connection with diethyl carbonate the lacquer solution of gums and nitrocellulose is apt to be too viscous. Lacquers containing diethyl carbonate as one of the solvents cannot be diluted with as much of the cheap hydrocarbon diluents, such as benzene, toluene, or xylene, as they can if a certain amount of ethyl lactate (a commonly used high boiler) is also contained in the mixture of solvents. Diethyl carbonate is excellent, especially in lacquers that are to be used on brass, as it seems to possess superior non-tarnishing qualities in connection with this metal.

Butyl alcohol (C_4H_9OH) is a medium-boiling gum-solvent, which is contained in fusel-oil and is separated from it by distillation. It is often manufactured from fermenting corn by special treatment. The boiling-point of butyl alcohol is 117°. Like other alcohols, it is an excellent solvent for many varnish-resins, but it does not dissolve nitrocellulose, the hard copals, or ester-gum. While its solvent action is less than that of the low-boiling anhydrous ethyl alcohol, it helps in forming good solvent mixtures with aromatic hydrocarbons used as diluents and with some of the esters which are often used to dissolve nitrocellulose.

The chief objection to the use of butyl alcohol as a lacquer-solvent is its mild but disagreeable choking odor, which is not as seriously objectionable as formerly because of better methods of manufacture. On account of its cheapness and availability, it is found in many lacquers, usually in a mixture with butyl acetate, an active solvent for nitrocellulose that seems to activate butyl alcohol and make it also an active solvent for nitrocellulose. Butyl alcohol is very valuable, however, because it has a low rate of evaporation, which helps it to flow better and to make a smoother and tougher film.

Butyl acetate, which also has a medium boiling-point, is one of the cheapest and most common lacquer-solvents that can be obtained easily on the market. It is a good solvent for nitrocellulose, and will dissolve some of the varnish-resins, such as dammar, mastic, elemi, rosin "E," and ester-gums. Some of the resins used in lacquers are insoluble in butyl acetate, among which are shellac, sandarac, and zanzibar, which are practically insoluble; and kauri and other copals, which are only slightly soluble when butyl acetate is used alone unmixed with other solvents.

Butyl acetate will stand more dilution in nitrocellulose mixtures with hydrocarbons than will diethyl carbonate, but it is inferior to monoethyl ether of ethylene glycol and ethyl lactate, which have dilution ratios about twice as high when toluene is used as a thinner. Butyl acetate is, however, greatly superior to ethyl acetate and ethyl alcohol in slowness of evaporation. The most serious defects of butyl acetate as a lacquer-solvent are its choking, disagreeable odor, its lack of absorptive power for water, and its inability to blend solutions containing resins with those containing nitrocellulose.

Amyl acetate ($CH_3COOC_5H_{11}$), an ester which helped in starting the lacquer industry, is another medium-boiling solvent which is made as a small by-product resulting from the manufacture of ethyl alcohol. Amyl acetate is the most important constituent of fusel-oil, which is an intermediate product coming from crude ethyl alcohol and is found only in small quantities in this substance; consequently the supply of amyl acetate is somewhat limited. It is an excellent solvent for nitrocellulose and many of the varnish-resins, but it dissolves shellac-gum only slightly. It has a very disagreeable and choking odor which tends to limit its use in lacquers. It gives good flowing qualities to lacquer, and allows of even greater dilution with hydrocarbon thinners than will butyl acetate which is frequently used in its place.

Ethyl lactate, a high-boiling active solvent, possesses certain of the qualities of an alcohol as well as some of an ester, and for this reason, probably, it has unusual solvent power for nitrocellulose. Its characteristics which are similar to those of the alcohols seem to explain why it will dissolve very completely such gums as shellac, rosin, pontianak, ester-gum, and kauri. Altho superior to other commonly used ester solvents in its dissolving power for most of the varnish-gums, its reaction on congo and dammar resins is slight. It has excellent properties as a blending agent for the two types of solutions, one containing nitrocellulose, and the other containing varnish-gums.

In addition to these good qualities, ethyl lactate when contained in a nitrocellulose lacquer will permit the solution to be thinned with more toluene or other hydrocarbon solvents than is possible with most of the other similar dissolving agents. Its use in a lacquer is also favored because it imparts a high gloss to the film. These good qualities together with its pleasant odor indicate that ethyl lactate will be much used as a high-boiling solvent in nitrocellulose lacquers.

Benzyl alcohol ($C_6H_5CH_2OH$) is another solvent in the high-boiling group, its boiling-point being 205° to 207° Centigrade. It has good dissolving powers for alcohol-soluble varnish-resins, and the so-called A.S. or alcohol-soluble nitrocellulose, which dissolves in slightly activated alcohol. It ranks higher than ethyl lactate as a resin solvent. It is, on the whole, a less powerful solvent than anhydrous ethyl alcohol. Other good qualities claimed for benzyl alcohol are that it helps in producing a good gloss on lacquer films, it has a pleasant odor, and it can be produced cheaply if made in large quantities. However, it has not been generally used by manufacturers. Benzyl alcohol is found in some of the oils of flowers such as the tuberose and jasmin. It is manufactured synthetically, and is sometimes used in the production of artificial perfume because of its weak and very sweet odor.

243. Plasticizers and Softeners.—Lacquers made from resins and nitrocellulose dissolved in the solvents that are ordinarily used are apt to be much too brittle, lack good adhesion, and will not flow well or become smooth on surfaces after being applied. It is to correct these defects, common to lacquers, and to impart a certain amount of plasticity which will permit a slight expansion and contraction of the film, that plasticizers and softeners are used.

Without plasticizers, lacquers dry, or rather set, so rapidly that it is practically impossible to apply them smoothly and evenly, especially with a brush. Very rapid drying or too much moisture in the air is apt to bring about another trouble known as *"blushing,"* a cloudy condition of the film produced by moisture, and the lowering of the temperature because of the rapid evaporation of the volatile solvents. If too much moisture condenses on a film, the nitrocellulose in the lacquer becomes no longer soluble and is precipitated from the solution. "Blushing" is not liable to occur, except when lacquer is applied during very rainy weather, unless the mixture lacks proper plasticizers.

The plasticizers and softeners should be solvents for both nitrocellulose and resins, and they must blend well in lacquer-mixtures. This blending of the solution of resins in their solvents, with the mixture of nitrocellulose in its solvents, helps to form a lasting union of the two solutions, and is one of the important functions of plasticizers.

Both plasticizers and softeners differ from solvents in one respect, in that they remain permanently in the varnish-like film after it is spread, while solvents evaporate leaving little or no residue. The plasticizers have a high boiling-point, usually above 300° C.; and, except for the residue left in the film, their characteristics are somewhat similar to those of the high-boiling solvents.

The purpose of the softeners in lacquer is to increase the adhesiveness and permanence of the film, and to cause it to be more tough, flexible, and elastic, thus allowing greater freedom for expansion and contraction.

The softeners that have found most favor in the lacquer industry in the past are castor-oil, rapeseed-oil, and camphor. The two oils, especially castor-oil, have been most successful in pyroxylin or nitrocellulose mixtures for use on artificial leathers. While castor-oil does soften and improve the flexibility of films made from such compounds, it has poor keeping qualities, and is liable to become rancid after a time. Another objection to the use of these oils in nitrocellulose lacquers is that they are not solvents for the varnish-resins which are generally used, nor for the nitrocellulose itself. Castor-oil is, however, soluble in alcohol, which is an ingredient of most lacquers.

The ideal softener should possess good stability or aging qualities, and should be a solvent for nitrocellulose and varnish-gums; therefore, such oils are not entirely satisfactory because they fail to meet these conditions. Camphor, altho the standard softener for many pyroxylin compounds, is not entirely satisfactory for use in lacquers on account of its great volatility and rather disagreeable odor. When castor-oil is contained in lacquers it is found in small quantities only, varying in amount from about one-half of one per cent to five or even seven per cent. The amount of camphor used as a softener also varies greatly, but rarely exceeds 25 per cent of the weight of the nitrocellulose in the lacquer. Treated China-wood oil, in amounts up to about seven per cent, has also been recommended as a softening agent which will give a lacquer film greater elasticity.

Chemists employed in the lacquer industry have investigated a large number of substances that have been proposed as plasticizers and softeners. At the present time, esters having high boiling-points and coming from phosphoric or some of the organic acids are favored, and take the place of both plasticizers and softeners which are terms often used without any very clear distinction or differentiation in meaning. The important advantages of these high-boiling esters over castor-oil and camphor are found in greater stability, and in solvent power for nitrocellulose.

The most commonly used esters which are made from phosphoric acid are triphenyl phosphate and tricresyl phosphate. Esters of the organic-acid type, such as those derived from phthalic (thăl′ic) acid, are now widely used, as plasticizers and are highly favored by experts. Diamyl phthalate, dibutyl phthalate, and diethyl phthalate are among the best of the present-day plasticizers, and have largely been substituted for castor-oil and camphor in the newer types of lacquers.[12] Dr. Keyes states that the phthalates seem to be superior to the phosphates, and that diamyl phthalate showed up better in tests than any of the other plasticizers.[13]

The phthalates are derivatives of phthalic acid, a white crystalline compound ($C_8H_6O_4$) which is produced by the oxidation of naphthalene, a well-known coal-tar product. When synthetic esters, such as the phthalates, are selected as the plasticizers in a lacquer-mixture they are often included in amounts up to 50 or 60 per cent and occasionally to 100 per cent by weight of the nitrocellulose content.

The elasticity of varnish-films comes from the slowly oxidizing oils which they contain. Old films always check after the oils have become largely oxidized or burned up. Such films are very brittle, for they lack the plastic element which they originally contained. It should be remembered that nitrocellulose lacquers usually contain no oils except those which sometimes function as softeners, and these are not much used at the present time. Nitrocellulose is not used in varnishes, but is an important ingredient in lacquers. Unfortunately, nitrocellulose, while making a film tough and strong, does not add a plastic element, such as that given to varnish by linseed-oil or China-wood oil.

Plasticizers and softeners, then, have important functions in lacquers. Without these substances to add elasticity, lacquers would be unfit for many uses. Even with the best lacquers, there is evidence to indicate that the films are not elastic enough to withstand changes of temperature and great variations in humidity. Especially is this true when they are spread on wood which expands and contracts to a measurable extent, particularly when placed outdoors where it is exposed to the sunlight and weather.

---

[12] See Bruce K. Brown, "The Use of Plasticizers in Lacquers," Industrial and Engineering Chemistry, Vol. XVII, No. 6, p. 568.

[13] See D. B. Keyes, "Solvents and Automobile Lacquers," Industrial and Engineering Chemistry, Vol. XVII, No. 6, p. 565.

Experience indicates that the best plasticizers and softeners are not entirely effective in eliminating temperature checks which come crosswise of the grain on wood,[14] because the lacquer-film varies in size with changes in temperature, while the wood lengthwise of the grain does not change appreciably in dimensions with either changes of temperature or humidity.[15] Lacquer-films are also liable to crack *with* the grain of wood, on account of changes of humidity in the atmosphere, and in the wood itself, which shrinks and swells across the grain or in width and thickness, thereby opening up longitudinal checks which do not entirely close after the coating is once ruptured. In their tendency to check, lacquers resemble ''short-oil'' varnishes, which are also deficient in plastic elements.

244. Diluents or Thinners.—When a thin lacquer having greater fluidity and less body or solid covering material is required, a diluent must be used. A thin lacquer spreads more easily and smoothly under a brush, and is much more satisfactory for ordinary use with a spray-gun, than is a thick or viscous lacquer. The reducers or diluents commonly kept in the finishing-room for thinning paints, shellac, varnish, and wood-filler should not be used. Paints may be diluted with linseed-oil and turpentine, shellac with alcohol, varnish with turpentine, and wood-filler with turpentine, naphtha, or benzine; but lacquer is a carefully compounded material containing various less well-known solvents which hold the nitrocellulose and varnish-gums in solution, and only a few of the cheaper hydrocarbon thinners can be introduced into such a mixture without great damage to the lacquer itself.

It is true that a certain amount of ethyl alcohol varying from 10 to 25 per cent is very frequently used as a solvent in compounding lacquer-mixtures; but any further increase in the amount of alcohol is liable to cause trouble, because alcohol is not an active solvent for nitrated lacquer cotton and very readily absorbs moisture from the air. Such an addition of water to a nitrocellulose film is a common cause of "blushing," or the precipitation of a gray or white substance, which ruins the transparency of a clear lacquer, and may change the color of a lacquer enamel. Petroleum naphtha and benzine must not be freely mixed into lacquers because, in excessive amount, they precipitate the nitrocellulose itself and ruin the lacquer completely. Linseed-oil seems to prevent proper drying qualities of lacquer-films, which remain tacky or sticky for a long time.

---

[14] See Paul S. Kennedy, "Problems for Research in Lacquer and Varnish," Furniture Manufacturer Magazine, Vol. XXIV, No. 6, p. 60.

[15] See A. C. Newell, *Wood and Lumber*, p. 138.

The proper thinners for use in lacquers are coal-tar derivatives, including such hydrocarbons as toluene, benzene, and xylene. (Benzene and benzine are different substances chemically, the latter being a petroleum distillate that must not be confused with benzene, which is derived from coal-tar.) Such thinners as toluene, benzene, and xylene are cheaper than the solvents which are used for dissolving nitrocellulose and varnish-resins, and are solvents for most of the gums commonly incorporated into lacquers.

It has been stated that a mixture of such resins as dammar, shellac, kauri, manila, and congo is very often used in compounding lacquers.[16] Of these resins, dammar is entirely soluble in benzol; shellac-gum is almost insoluble in this hydrocarbon solvent; kauri is about 67 per cent soluble; and manila and congo are 60 per cent soluble. Of the other varnish-resins sometimes selected for incorporating into lacquers, elemi and mastic are entirely soluble in benzol, while thus, cumar, and ester gums are largely soluble. (Benzol is a mixture of benzene, toluene, and xylene, which often contains 70 per cent of benzene, and from 24 to 27 per cent of toluene, the balance being xylene.)

The amount of benzene, toluene, and xylene that can be added to lacquer-mixtures is limited because these hydrocarbons are not solvents for nitrocellulose. These diluents, however, act as blending-agents for the two mixtures; one of which is made of solutions of varnish resins in their selected solvents, and the other nitrocellulose in its solvents.

---

[16] See Section 241, "Varnish-Resins Used in Lacquers," p. 291.

When added in limited quantities, suitable diluents help in keeping the mixed lacquer clear by removal of cloudiness. The user of lacquer should be warned that large quantities of benzene, toluene, or xylene must not be used to thin the mixture, because these hydrocarbons tend to jelly or coagulate the nitrocellulose solution, and may even cause a precipitation of this substance. Benzene, a low boiler having a boiling-point of 80° C., can be added to lacquer in larger quantities than can toluene, a medium boiler with a boiling-point of 111° C., or xylene, a high boiler which boils at about 143° C. It should be noted, however, that the high boiler, xylene, tends to make a lacquer film dry more slowly because of slower evaporation than that which takes place when toluene is used, and that the latter substance causes slower drying and evaporation than when benzene is the diluent used.

Toluene is considered by many manufacturers the most satisfactory of all of the lacquer diluents. Recently, its use has increased and, according to one writer, toluene is now incorporated into lacquers in amount about equal to that of all other thinners and solvent ingredients combined.[17]

Without diluents lacquers would be so expensive that their use would be very limited. The solvents that are necessary for dissolving nitrocellulose and varnish-gums, and for producing solutions that will blend, cost more than those used in an equal amount of enamel, varnish, or shellac; consequently lacquers cost more than these other finishes. Even tho a limited amount of diluents, often varying from 35 to 45 per cent of the total weight of the lacquer, is used in manufacturing these quick-drying finishes, they are more expensive, in general, than varnishes and enamels.

Diluents have no permanent function in lacquer-films

---

[17] See H. C. Maugey, "Automobile Finishes," Industrial and Engineering Chemistry Magazine, Vol. XIX, No. 10, October, 1927, p. 1102.

TABLE VII.

GENERAL FORMULA FOR LACQUER

Class of Ingredients	Name of Ingredient	Chemical and General Information	Amount Used	Special Function in Lacquers
Solids which remain in the film. (20% to 30% by weight not including pigments.)	1. *Nitrocellulose.* Two types: A. S., soluble in alcohol slightly activated. R. S., soluble in esters, especially acetates.	Made from Cotton linters, ½ second viscocity. Regular Soluble. Nitrated with treatments of nitric and sulphuric acid to 11.9% to 12.1%.	Varies from 6 oz. to 32 oz. Usually 8 oz. to 16 oz. per gallon of liquid.	To form a film that is colorless, tough, hard, viscous, and varnishlike, but brittle. To act as a tough, hard binder for the gums. It has functions similar to those of drying-oils in oil-varnishes.
	2. *Varnish-resins,* or gums—ester-gum and and dammar, usually; sometimes shellac and rosin, kauri and shellac; occasionally manila gum or pontianak.	Gums used are largely alcohol-soluble. Ester-gum is a synthetic product. Mixture of two gums, usually, preferred because cheap ester-gum makes a chalky film.	Varies from 50% to 200% of weight of nitrocellulose. Many lacquers have weight of gums about equal to weight of nitrocellulose. Spraying-lacquers have less gum.	To increase "body" or solid content, to add adhesiveness, to reduce cost, to produce more gloss, to make rubbing possible.
	3. *Plasticizers.*	High-boiling esters—dibutyl phthalate most common. Other phthalates, tricresyl phosphate, castor-oil, and other oils sometimes used.	Varies from 16% to 100% of weight of nitrocellulose. Lacquers with high gum and pigment content have more plasticizer.	Produce films that are more plastic, softer, less brittle. They increase flow, remain in the film, retard time of setting, prevent blushing and cracking.

TABLE VII.—Continued

GENERAL FORMULA FOR LACQUER

Class of Ingredients	Name of Ingredient	Chemical and General Information	Amount Used	Special Function in Lacquers
SOLVENTS FOR NITROCELLULOSE	Ethyl acetate.	Low boiler, 77° C. Small amounts or none used in brushing-lacquers.	Varies from 2% to 25% when used.	To dissolve nitrocellulose. Produce quick drying. Reduce cost. To help in spreading.
	Butyl acetate generally used. Butyl propionate, diethyl carbonate, and amyl acetate. Sometimes used.	Medium boiler, 125° C. Usually are esters such as acetates. Most important nitrocellulose solvents. Most commonly used solvents for both spraying- and brushing-lacquers.	Varies from 15% to 40% and is found in many formulas.	To produce smooth flow. To reduce brittleness and blushing. To retard setting.
Evaporate	Ethyl lactate.	High boiler, 152° C. Evaporates slowly, and is sometimes used in brushing-lacquers.	Varies from 2% to 4% of total liquid when used at all.	To retard setting and drying of the films. To improve flowing and brushing qualities. To prevent blushing.
GUM SOLVENTS	Anhydrous ethyl alcohol.	Low boiler, 78° C. All nitrocellulose is shipped wet with alcohol — 70 lbs. of nitrocellulose and 30 lbs. of alcohol.	Varies from 3% to 63% of the liquids. Large amount may cause blushing.	To dissolve varnish-gums. Solvent for A. S. nitrocellulose when activated with an ester such as butyl acetate.

TABLE VII.—Continued

General Formula for Lacquer

Class of Ingredients	Name of Ingredient	Chemical and General Information	Amount Used	Special Function in Lacquers
GUM-SOLVENTS Often called non-solvents for nitrocellulose. Evaporate	Butyl alcohol, also called Butanol.	Medium boiler, 117° C. Often used in lacquers and becomes an active solvent for nitrocellulose when activated with butyl acetate.	Varies from 5% to 25%, with 10% most common.	Solvent for varnish-resins and gives flow to lacquers. To help prevent blushing. To add good brushing-qualities.
	Amyl alcohol, also called Pentasol.	Medium boiler, 126° to 132° C. Good solvent for nitrocellulose when activated with amyl acetate.	Varies usually from 4.5% to 10% of liquids.	To impart flow to lacquers. Solvent for gums.
DILUENTS Solvents for gums; also thinners. Evaporate.	Toluol or Toluene	Distils at 111° C. It is the most generally used hydrocarbon thinner or diluent.	Usually between 30% and 55% of liquids when xylol is not used.	To act as a thinner and gum solvent. To cheapen the lacquer. To blend the other mixtures.
	Xylol or Xylene.	Distils at 143° C. Often used with toluol in a mixture.	Generally between 30% and 60% of liquids when toluol is not mixed with it; 40% is commonly used.	To act as a thinner and gum solvent. To retard the drying of the film and cheapen the lacquer. To blend the gum and nitrocellulose mixtures.

after the latter are spread, because they soon evaporate, leaving practically no residue in the finish itself.

245. General Formula for Lacquer.—The preceding general formula for nitrocellulose lacquer, Table VII, gives much information about the ingredients found in lacquers, their special functions, and the amount of each that is used.

246. Clear Brushing-Lacquer for Wood.—The following formula gives an idea of the composition of an unpigmented brushing-lacquer:

Solids:

Nitrocellulose, ½ second R.S. (Regular Soluble) nitrocotton, 8 oz.
Gums: Dammar (High-grade), 5 oz.
Ester-gum, 3 oz.
Plasticizer, Dibutyl Phthalate, 3 oz.

Liquids; total, 1 gallon:

Solvent for Nitrocellulose: Butyl propionate, 15%
Butyl acetate, 15%
Nonsolvent, Butyl alcohol, 20%
Diluents: Toluol, 20%
Xylol, 30%

Spraying-lacquers are not so much like varnishes as are brushing-lacquers, and contain a smaller percent of gums relatively to the amount of nitrocellulose.

247. Formula for High-Grade Spraying-Lacquer.—

Solids:

Nitrocellulose: R.S. (Regular Soluble), ½ second viscosity, Cotton, 20 oz.
Gums: Dammar, High-grade (Grade A Batavia or Singapore), 5 oz.
Ester-gum, 5 oz.
Plasticizer: Dibutyl Phthalate, 8 oz.

Liquids; total, 1 gallon:

Solvent for Nitrocellulose: Butyl acetate, 35%
Nonsolvents: Butanol (Butyl alcohol), 15%
Ethyl alcohol (Anhydrous), 10%
Diluents: Toluol (Toluene), 30%
Xylol (Xylene), 10%

Pigments properly prepared are often added to make lacquer-enamels. The amount of pigment added varies greatly. A white lacquer-enamel might be prepared by adding 32 ounces of zinc oxide to the above mixture. A black lacquer might be made by mixing 3¼ to 4 ounces of Super Spectra Black with an equal amount of castor-oil and adding to the gallon of lacquer. Even Carbon Black is sometimes used. Colored pigments in amounts varying from 12 to 18 ounces mixed with oil plasticizers may be used in making lacquer-enamels. The manufacturers have special equipment for grinding colors for use with lacquers in order to secure fineness and perfect mixture.

While it may be true that a formula for clear lacquers may seem to be easy to prepare, there are many details of manufacture that are complex, and expensive equipment is needed; consequently the work should be done under the direction of trained and experienced chemists. The preparation of colors for use in lacquer-enamels is also a technical process that should be left to factory experts.

Automobile-lacquers for spraying usually have more nitrocellulose relatively to the resins than is the case of wood-lacquers which contain a higher percentage of resins. Wood-lacquers are therefore more like varnishes, and the films have more body and gloss than automobile-lacquers.

248. Clear or Transparent Lacquers.—Wood-finishers sometimes wonder why the manufacturers do not recommend lacquer in its clear or transparent form for outdoor use while their lacquer-enamels are especially advertised as being superior for such use. Experts have come to the conclusion that nitrocellulose, when included to the extent of about 50 per cent of the solid material in lacquer, easily and rapidly changes or decomposes in direct sunlight, or on being exposed to outside weather conditions.

On the inside of buildings, where the ultra-violet rays of sunlight have been removed by filtering thru window-glass, clear lacquers do not break down chemically or physically, and can be used with satisfaction. These clear lacquers, which are enduring for indoor use, cannot be used over lacquer-enamels on automobiles in order to give a higher gloss to the finish, because of the intense actinic action of the ultra-violet sunlight rays. Manufacturers and their chemists are hoping to solve this problem and make it possible to produce a higher luster on lacquer-enamel finishes, which are always much duller than varnish finishes.[18]

Varnishes have been tried over lacquer enamels, the finisher hoping thus to secure a greater luster or higher gloss, but without success. Mr. Kennedy reports, in the reference just cited, that a new clear "varnish-lacquer," containing pretreated varnish and high-grade vegetable oils, is now being tried with strong indications of success, altho the tests are still in an experimental stage.

It is probable that in the near future clear lacquers may contain some chemical ingredient which will act as an ultra-violet-ray filter for sunlight. Other methods for making a clear lacquer that is durable in sunlight are receiving the attention of chemists, such as replacing part of the nitrocellulose by another ingredient which will serve as a filter for destructive rays, or finding a substitute for the nitrocellulose itself.

Clear lacquer-finishes are beautiful, and are durable on wooden furniture which is kept at a uniform temperature and not exposed to extremes of humidity. The tough hard lacquer-films do not stretch and contract readily, and are liable to become checked because the film ruptures with great changes in temperature or humidity.

249. Lacquer-Enamels and Colored Lacquers. — Pigments in white, black, and various colors are often added to clear or transparent lacquers, if obscuration and a change in hue or tone are desired with a quick-drying finish. The addition of pigments gives lacquer a resistance to the actinic rays of sunlight, and has made lacquer-enamels successful for outdoor use. It is well-known, however, that clear lacquer will not give service under such conditions.

Pigmented lacquers can be purchased in most of the hues including a great variety of tints and shades. If the three primary colors—red, yellow, and blue—in addition to black and white, are kept on hand, a colorist can mix almost any color which he desires, just as is done with paints or enamels. This statement means that the lacquer enamels can be mixed together to produce other colors. It does not mean that painters' colors which are ground in oil can be added to clear or transparent lacquer or to white lacquer-enamel. This should not be done, because the oil vehicle in which the pigments are ground does not mix properly with nitrocellulose mixtures. If one wishes to add new coloring pigments he can obtain the best results by securing colors ground in japan rather than those ground in oil.

---

[18] See Paul S. Kennedy, "Problems for Research in Lacquer and Varnish," Furniture Manufacturer Magazine, Vol. XXXIV, No. 6, December, 1927, pp. 62, 3.

House-painters and wood-finishers usually obtain the various hues desired from oil-ground colors, while sign-painters, wagon-, carriage-, and automobile-painters commonly select colors ground in japan for their work. Grinding-japan is a very quick-drying varnish, which is made from some resin such as shellac or rosin, a linseed-oil vehicle, and a solvent together with metallic oxides which are known as driers. Such japans are thinned when necessary with a very quick-drying liquid, turpentine being the most satisfactory.

A lacquer which contains a white pigment that will produce obscuration of the surface can be colored by the use of various coal-tar dyes soluble in alcohol. While spirit-soluble dyes which are liable to fade in sunlight are sometimes incorporated into a transparent lacquer, pigment-colors ground in japan are the materials most satisfactory for a practical finisher to add to lacquer enamels. Good results can undoubtedly be secured by adding japan-ground colors to a lacquer-thinner, and then incorporating this pigmented mixture into a clear lacquer. This method is suggested by one manufacturer, but the novice is more apt to secure good results by purchasing ready-prepared pigmented lacquers and mixing together colors of the same brand only.[19]

Pigments may be incorporated into lacquers during the manufacturing process by several quite different processes. If castor-oil or some other specially prepared oil is used as a plasticizer, the oil and the colors may be ground together and added to the lacquer-mixture.[20] Sometimes the pigments are rolled into a heavy plastic mass of nitrocellulose containing a portion of its solvents. More of the solvents are added to the colored or pigmented nitrocellulose mixture after the heavy steel rollers have thoroly amalgamated the pigments and nitrocellulose into a very homogeneous mass. The other lacquer ingredients, such as the resins in solutions, plasticizers, and diluents, are thus compounded with the pigmented nitro-cotton mixture.

---

[19] See The Zapon Company, *Zapon Lacquer Finish for Furniture,* "Color Coats," p. 27.

Other methods are also used by manufacturers, some of whom grind the pigments with certain amounts of completely compounded clear lacquer, the grinding being done in pebble mills.[21] Another plan is to grind the pigments with some of the lacquer-reducers, and add this mixture to heavy clear lacquer. In general, it is wise to let the factory expert mix the pigments into lacquers, because he has the proper skill, knowledge, and equipment for such work. The danger from the use of colors ground in japan comes from linseed-oil which is ordinarily found in most japans. Linseed-oil does not usually react well in lacquers, tho it is sometimes used in small quantities.

Pigments are of great value in lacquers in addition to their coloring function; and, because of their presence in lacquer-enamels, these finishes can be used outdoors successfully on automobiles, particularly. Clear or transparent lacquers, however, do not wear well when exposed to bright sunlight. The pigments in lacquer-enamels seem to absorb the ultra-violet rays, and prevent their destructive action, which seems to be a decomposition of the nitrocellulose component of the film.

While it is true that pigmented lacquers gradually are affected with old-age checks when used on automobiles, they have proved to be long-lived compared with enamel and varnish finishes, except where enamel is baked on. Most of the large automobile factories have adopted some type of lacquer-enamel, or pyroxylin, as the most durable and satisfactory motor-car finish thus far produced.

---

[20] See F. Sproxton, *Cellulose Ester-Varnishes*, p. 131.

[21] See The Glidden Company, *The Finishing of Wood with No. 35 Wood Lacquer*, p. 12.

Colored lacquers differ from lacquer-enamels in much the same way that water-stains are different from pigmented oil-stains. In the case of water-stains, a transparent dye is used for coloring-matter, while an opaque pigment, possessing more or less obscuration for any surface on which it is placed, is the color-giving material in pigmented oil-stains. Colored lacquers are manufactured by adding spirit-soluble coal-tar dyes to clear lacquers. Electric-light bulbs and other articles of glass, besides ornamental metalwork, are often colored with an attractive translucent effect which is produced by dyed lacquers.

REFERENCES—CHAPTER XV

LACQUERS—HISTORY, USES, AND COMPOSITION

American Paint Journal Company (St. Louis, Mo.), *A Lacquer Catechism.*

J. Gauld Bearn, *The Chemistry of Paints, Pigments, and Varnishes,* Chapter XIX, pp. 236, 7.

Bruce K. Brown, "The Use of Plasticizers in Lacquers," Industrial and Engineering Chemistry, Vol. XVII, No. 6, June, 1925, pp. 568-9.

Ch. Coffignier, *Colors and Varnishes,* Chapter XV, "Nitrocellulose Varnishes," p. 229; "Lacquers," p. 242.

Commercial Solvents Corporation (Terre Haute, Indiana), *"Butanol in Lacquers."*

J. G. Davidson, "The Glycol Ethers and Their Use in the Lacquer Industry," Industrial and Engineering Chemistry, Vol. XVIII, No. 7, July, 1926, pp. 669-75.

G. B. Heckel, *A Varnish Catechism for Varnish Men* (Fifth Edition, 1927), pp. 39-42.

Paul S. Kennedy, "Problems for Research in Lacquer and Varnish," Furniture Manufacturer Magazine, Vol. XXXIV, No. 6, December, 1927, pp. 60-4.

D. B. Keyes, "Solvents and Automobile-Lacquers," Industrial and Engineering Chemistry, Vol. XVII, No. 6, June, 1925, pp. 558-67.

D. B. Keyes, "Two-Type Lacquer-Solvents," Industrial and Engineering Chemistry, Vol. XVII, No. 11, pp. 1120-2.

R. A. McGee and A. G. Brown, *Instruction Units in Wood-Finishing,* Unit No. 5, "To Apply a Lacquer-Finish," pp. 36-39.

R. S. Morrell and A. de Waele, *Rubber, Resins, Paints, and Varnishes,* Section IV, "Cellulose Ester-Varnishes," pp. 219-21.

Paul M. Mowen, "Gums Suitable for Pyroxylin Lacquers," Paint, Oil, and Chemical Review, May 10, 1928, pp. 10-11.

H. C. Mougey, "Automobile Finishes," Industrial and Engineering Chemistry, Vol. XIX, No. 10, October, 1927, pp. 1102-3.

Glenn H. Pickard (American Paint Journal Company, St. Louis, Mo.), *Lacquers.*

A. H. Sabin, *Technology of Paint and Varnish* (3rd edition, 1927), "Pyroxylin Finishes," pp. 141-8.

Walter K. Schmidt, "Review of Developments in Wood-Lacquers," Furniture Manufacturer Magazine, Vol. XXXIII, No. 3, March, 1927, p. 68.

Winfield G. Scott, *Formulas and Processes for Manufacturing Paints, Oils, and Varnishes,* pp. 211-15.

United States Industrial Chemical Company (Peoria, Illinois), *Solvents, Cotton Solutions, and Plasticizers.*

F. N. Vanderwalker, *Wood-Finishing, Plain and Decorative,* "Lacquers," pp. 231-7.

Samuel P. Wilson, *Pyroxylin Enamels and Lacquers* (Second edition, 1927).

CHAPTER XVI

LACQUER FINISHES AND LACQUER TECHNIC

250. Advantages of Lacquers Over Varnishes and Enamels.—Many advantages of lacquers and lacquer enamels over varnishes and varnish-enamels have been advanced by manufacturers and enthusiastic users of these new quick-drying nitrocellulose finishes. They are very valuable for certain kinds of work, but their use has been misunderstood; and, in the hands of novices, there have been many failures. The advantages that seem to be conspicuous to users and manufacturers are listed as follows:

1. Lacquers set quickly and dry hard sooner than varnishes; consequently production can be speeded up, and less floor space for drying is needed.

2. They dry to a very stable, almost unchangeable hardness thru evaporation.

3. Their rapid drying avoids dust specks which are so troublesome with varnish.

4. They do not oxidize and crumble away after a time as oil-varnishes always do. In other words, chemical action ceases in lacquer-films after they harden.

5. When used with intelligence, lacquer-coatings are very durable and long-lived, comparing favorably with the best of the varnishes and enamels.

6. Lacquer-finishes wear well under exposure or use, and are not easily affected by soap, dilute alcohol, or weak acids, oils, road-tar, water or ice, by reasonable changes in temperature, or by the reduced actinic action of indoor sunlight.

7. Pigmented-lacquers wear well, and are not easily checked by exposure to the ultra-violet rays of outdoor sunlight.

8. Films of lacquer do not change in tone or shade while drying.

9. Lacquer-finishes dry with a soft satinlike luster or low gloss.

10. Coatings of lacquer are about as moisture-proof as similar films of spar-varnish.

11. The best lacquer-finishes resist rather high temperature without becoming soft or tacky; consequently, they are not usually seriously affected by hot dishes or even by boiling water. Repeated abuse thru heat, however, may cause temperature checks which will always show, as the edges of the cracks do not reunite later on.

251. Disadvantages of Lacquer-Finishes.—The user of nitrocellulose lacquer should be informed about the difficulties of applying it, and about some of the shortcomings of the material as a finishing-medium. The chemical composition of lacquers prohibits their use under certain conditions.

The novice can use paint, shellac, and varnish by placing coats of any of them over or under, and no serious chemical reactions are ordinarily produced; but with lacquer one must carefully consider what is to go under or over it, or serious trouble may follow.

The chief disadvantages of lacquer-finishes, in the opinion of experienced finishers, may be listed as follows:

1. Lacquers are very difficult to apply with brushes, because all such finishes set and dry too quickly.

2. Clear lacquers show a tendency to shrink in drying because of absorption by the undercoats, or on account of evaporation of the high-boiling solvents, which are the last of the volatile elements to leave the film. This shrinking makes the problem of the filling up of the large cell openings of very porous woods exceedingly difficult.

3. Undercoats of varnish, enamel, oil, wax, or paint cannot be used directly under lacquer-coatings, because some of the solvents in the lacquer are the same as, or similar to, the liquids in paint-and-varnish removers; consequently they will soften and destroy such finishes. Covering the undercoats with shellac of standard strength, or even with

a considerably thinned mixture, usually, will protect them from the destructive action of lacquer-solvents.

4. Lacquers should not be applied directly over surfaces that have been finished with linseed-oil stains or ordinary wood-fillers, because of bleeding and streaking into the upper coats thru the action of the solvents upon the linseed-oil in the undercoats. Under lacquer-finishes, water-stains, and special wood-fillers containing the minimum of linseed-oil should be used. A coating of shellac over a surface filled with ordinary wood-filler will, to a large extent, protect it from damage by the lacquer-solvents.

5. Spirit-soluble stains cannot be used satisfactorily directly under clear lacquer-finishes without danger of muddy effects.

6. Lacquer-finishes must be rather thin when applied; consequently they have a reduced body or depth, and a greater number of coats is required.

7. A high gloss similar to that obtained from rubbing- and polishing-varnishes cannot be obtained from lacquers. The highest gloss can be secured by giving a final coat of clear lacquer; but, unfortunately, such a transparent film cannot be applied over pigmented lacquers for outdoor use because of the destructive action of the ultra-violet rays of summer sunlight, which causes serious checking of the non-colored finishing-coat.

8. Lacquer-films over wood sometimes check crosswise on account of temperature changes; or, more often, they crack parallel with the grain because of shrinking and swelling of the wood. These changes in size, of course, are caused by variations in humidity.

252. Undercoats for Lacquers.—The complex nature of lacquers, which include several powerful solvents as necessary ingredients, makes it imperative that only such undercoats be used as are not easily softened, dissolved, or changed chemically by the application of films of lacquer. Experienced finishers have discovered, however, that sometimes lacquers can be sprayed over certain undercoats with less likelihood of trouble than when brushes are used for spreading it.

The user of lacquer should remember that there are generally several very powerful solvents in any lacquer mixture. If one knows that such ingredients as ethyl alcohol, butyl alcohol, and other alcohols, ethyl acetate, butyl acetate, amyl acetate, and the various ethers of ethylene and propylene glycol, besides other substances of great dissolving possibilities, are used commonly as solvents for the nitrocellulose and resins which give body to a lacquer, he will realize that these complex finishes are very apt to have the softening action of paint-and-varnish removers, and that they cannot be applied directly over new finishes—particularly paints, oleoresinous varnishes, wood-fillers, and oil-finishes.

Linseed-oil in films oxidizes very gradually, and finishes containing it dry slowly and do not become hard for a long period of time. The oxidation of the oil changes it chemically into varnishlike materials which are quite different from the original organic compound. Linseed-oil in its liquid form is easily soluble in most of the lacquer-solvents. The oil in newly-made films of finishes, tho apparently dry after a few days, is really only partially oxidized, and is still soluble in most of the solvents in nitrocellulose lacquers.

For these reasons, lacquers cannot be used directly over any finish which contains linseed-oil until months have passed, and the oil has oxidized so completely that it has lost its solubility to a great extent, and is not easily softened by solvents. Paints, oil-varnishes, oil-finishes, ordinary wood-fillers, and varnish-enamels to a limited extent, all contain linseed-oil in varying amounts. While they are new, films made from any of these finishes cannot be covered with nitrocellulose lacquers without some intervening coat to separate the solvents in the lacquer from the undercoats, thus preventing destructive action on the linseed-oil.

Special wood-fillers are now prepared for use immediately under clear lacquers on porous woods when natural finishes are desired. These fillers are similar to other wood-fillers, but should contain minimum amounts of linseed-oil and drier.[1] Ordinary paste wood-fillers are satisfactory, however, if coated with shellac before applying lacquer.

On automobiles, special oil primers and surfacers should be used under the lacquer finishes. Primers of proper composition should be used between the final lacquer-coats and the undercoats which contain a certain amount of oil.

Several manufacturers furnish specially prepared undercoating finishes which are intended to be placed between lacquer-films and the previously applied wood-fillers. Spirit-varnish gums, such as shellac, which do not readily dissolve in the lacquer-solvents, are selected as the proper resins for these special surfacers.

Shellac, in liquid form which is sometimes called shellac-varnish, is an effective and convenient surfacer to place over wood-filler or other oil-containing undercoats, thus protecting them from the final coat or coats of lacquer. Shellac-varnish is made from 190° proof denatured alcohol and shellac-gum. Ethyl alcohol does not dissolve linseed-oil; therefore, it is a good solvent for a surfacer which is used to cover any of the undercoats containing this oil.

When the function of a coating of shellac-varnish over stains and wood-filler is chiefly that of a sizing to protect the undercoats from lacquer, it is often advisable to dilute the factory-made four-pound cut liquid shellac to one-half strength, tho thinner or thicker mixtures may be used. The stronger mixtures tend to give more body to the finish and, in some cases, are preferred because the lacquer-films are in general much thinner than coats of rubbing-varnish.

Films of shellac-varnish are not readily dissolved by coatings of the standard lacquers of today, because shellac-resin or gum, as it is frequently called, is not easily soluble in many of the lacquer-solvents. Shellac-gum is only slightly soluble in ether, amyl acetate, most of the glycols, and some of the other lacquer-solvents, or in benzol which is a combination of the diluents, benzene, toluene, and xylene.

---

[1] See Samuel P. Wilson, *Pyroxylin Enamels and Lacquers* (Second edition, 1927), pp. 148, 149, 203.

These hydrocarbon thinners are generally used in quantities that amount to about 35 to 50 per cent of the entire weight of a lacquer-mixture. While shellac-gum is soluble in strong ethyl alcohol, butyl alcohol, ethyl acetate, and some other solvents frequently incorporated into nitrocellulose lacquer compounds, it must be remembered that these ingredients which will dissolve shellac-gum are very volatile, and evaporate quickly from a thin coating such as a film of lacquer.[2] It has already been stated that ethyl alcohol and ethyl acetate belong to the low-boiling, quick-evaporating group of solvents. Butyl alcohol is a medium boiler, and is used because it is cheap and available, but its odor is disagreeable, and its use in lacquers may decrease with the discovery of better solvents.

Tho it is known that in a liquid state shellac and lacquers usually mix together satisfactorily, it has been found by experiment that lacquer can be spread over thoroly-dry coatings of shellac-varnish without appreciably affecting the shellac-film itself. While the hardened coat of shellac may be softened somewhat, it will not be dissolved and worked into the lacquer film if the latter is applied quickly with a brush or is sprayed over the surface. The relative amount of solvents in most lacquers that will dissolve shellac-gum is not great, and these liquids leave the surface with exceptional rapidity on account of their volatility.

New coats of oil-varnish cannot be used successfully under lacquers, because the solvents contained in these nitrocellulose finishes may dissolve any unoxidized linseed-oil contained in a varnish undercoat. Undercoats of varnish containing tung-oil are apt to become wrinkled or blistered by applying lacquer over them. The strong lacquer-solvents may even soften and roughen the resins in the undercoats, some of which are like kauri-gum in that they are soluble, or at least partly dissolvable, in both the solvents and diluents that are used in making the lacquer.

---

[2] See J. G. Davidson, "The Glycol Ethers and Their Use in the Lacquer Industry," Industrial and Engineering Chemistry, Vol. XVIII, No. 7, p. 671.

If a coat of varnish or enamel has dried hard, or is several years old and the drying-oils have changed thru oxidation, the best of the latest lacquers can usually be applied without difficulty. Lacquer-enamels are successfully sprayed over old enamel-finishes on automobiles if the enamel and varnish coats are not loose or too badly checked. Varnish or enamel undercoats, however, may cause trouble later on; therefore, they should be avoided on important refinishing jobs.

The proper stains for use on wood under clear lacquers are the various kinds of water-soluble dyes.[3] Acid water-soluble coal-tar dyes are satisfactory, easily obtainable, and are generally used for staining wood, because such colors are among the most permanent known. Another reason for the use of water-stains is that lacquers and other finishes can be coated over them without an uneven muddy effect, which would happen in case the lacquer-solvents dissolved any of the stain in the undercoating.

Mahogany stains are not recommended for use under lacquer, because many of them will "bleed" thru a shellac sizing, or even thru a heavy film, into a lacquer finishing-coat and spoil it. Oil and spirit coal-tar dyes are not recommended for staining under lacquer; but they can sometimes be used, if thoroly protected by coats of shellac before any lacquer is applied. Water-stains are most satisfactory for general use, and are recommended by some authorities as the only proper stains to use under lacquer.

253. Application of Lacquers.—The self-confident person who thinks that he can do almost anything is very apt have some of the conceit taken out of him the first time he attempts to apply lacquer with a brush over a large surface. It is true that there are some brands of lacquer on the market which are slower in setting than others, but there is room for improvement in the brushing-qualities of practically all nitrocellulose finishes. Lacquers are attractive in their effects, but they are the most difficult of all wood-finishes to apply with a brush. Altho not easy to spread by hand, they can be sprayed very successfully with an air-gun and proper pressure. Spraying is the method used almost exclusively for covering large surfaces.

---

[3] See Samuel P. Wilson, *Pyroxylin Enamels and Lacquers*, "Staining of Wood," p. 202.

A surface over which lacquer is to be coated must be prepared properly; it must be clean, dry, and smooth. Water-stains are liable to expand wood, because they add humidity. After staining with water-stains, articles made of wood should be allowed to dry at least 24 hours in a warm, dry room in order to allow all excess of moisture to evaporate.

Metal surfaces which are to be lacquered must be carefully cleansed and brightened. Small areas may be prepared with sandpaper, but large surfaces are usually treated with a sand-blast.

If it is desired to refinish old surfaces with lacquers, it is necessary that they be properly cleansed, preferably with turpentine, in order to remove any grease, oil, wax, or polish which may be left on the old finish. In general, old varnish, shellac, enamel, or other hard finishes should be sanded to perfect smoothness. This treatment, in which No. 00 to No. 0000 sandpaper is used, also removes the gloss from the old finish, and helps new coats to adhere to the undercoats.

Surfaces which are checked, or are rough and contain spots partly peeled off, must be smoothed over with fine sandpaper or steel wool of fine grade.

Sometimes both clear lacquers and lacquer-enamels have proved very unsatisfactory when applied over old varnish or enamel-finishes. Lacquer-finishes when applied over undercoats containing varnish are very apt to check badly or peel off after a few months, and sometimes trouble has appeared within several weeks.[4] Experiments indicate that lacquer-finishes are satisfactory when spread over proper undercoats, and that old varnish and enamel undercoats should not be used in important refinishing.

254. Spreading Lacquer with a Brush.—The happy selection of a proper brush is often helpful in the application of several of the types of finishes for wood. When lacquer is to be applied by hand, it is particularly important that a suitable brush be chosen. The brush should not be too soft nor too stiff and coarse. A medium-soft fitch-brush of good quality, vulcanized in rubber and rubber-bound, is well adapted for spreading lacquers.

Fitch-brushes were originally made from the hair obtained from the tails of American skunks, but in order to secure more elasticity many manufacturers mix the soft skunk-hair with other stiffer hair or even with Chinese-boar bristles. The medium-soft grades of high-quality brushes for shellac and varnish which are made from the best bristles from China are usually the most satisfactory brushes for use with brushing-lacquers. Camel's hair brushes, now generally made from the tail-hair of Siberian squirrels, are too soft for use with brushing-lacquers.

All things considered, the best brush for spreading lacquer is a large cement-set or rubber-set oval or flat varnish-brush made from medium-soft bristles of good quality. The ordinary cheap varnish-brush, which is apt to be made from coarse black Russian or Chinese boar bristles, is too stiff to use in applying lacquers because it is liable to roughen an undercoat which may be softened by solvents in the lacquer.

The following suggestions may be helpful to persons without experience who wish to apply lacquer with a brush:

1. Proper undercoats are absolutely necessary. Shellac or special lacquer undercoats should generally be used over other finishes before lacquer is applied. On new, unfinished wood, shellac makes a good sizing which will seal up

---

[4] See Ralph G. Waring, "Modern Lacquer Materials and Their Application," The Industrial-Arts Magazine, Vol. XVI, No. 4, April, 1927, pp. 134-137.

the pores of the wood and help to give "body" to a lacquer-finish.

2. Brushing-lacquer must be applied very rapidly and carefully, using a brush or brushes of the proper size. Each stroke of the brush should completely cover a certain area as the lacquer is flowed on the surface. Much brushing after the manner of applying wood-filler must be avoided.

3. The brush must be kept wet or full of lacquer while in use, and should be wiped on the point only after refilling from the can or pail.

4. Open-grained or porous woods must be filled properly, and surfaced with shellac or a specially-prepared lacquer undercoat, in order to make level surfaces, because lacquer does not flow into the cell-openings and fill them as other finishes do.

5. Brushing-lacquer must be flowed over a surface with a wet brush held at an oblique angle instead of perpendicularly to the surface. Lacquer is always flowed over a surface and cannot be "brushed out."

6. The finisher must stand in a position that will enable him to see well, because the surfaces must be covered properly and completely at the first application. Retouching improperly covered spots after the lacquer has set even for a few seconds will produce a rough finish wherever the brush touches the edges of the partly-dried films surrounding the unfinished area.

7. All removable doors and all pieces of furniture, whenever possible, should be placed in such a position that lacquer can be applied on horizontal rather than on vertical surfaces. It is possible to apply thicker coats to horizontal than to vertical surfaces, and there is much less danger of runs and sags. This method results in superior smoothness and evenness. Lacquer sets so rapidly that the first side of an article will dry hard enough to handle in a few minutes, then another side can be placed in a horizontal position ready for lacquering under the most favorable conditions.

8. Whenever it becomes necessary to join a partly-set

lacquer-film to a new wet coating, it is best to soften the edge that has begun to thicken by the use of another brush and lacquer reduced to one-half strength with thinner. This procedure will usually prevent roughness where the lap of the newly lacquered film joins the partly-set edge of the coating previously applied.

9. If lacquer does not spread freely under a brush, it is often advantageous to thin the mixture with a thinner, which can be secured from the lacquer manufacturer.

10. A small amount of thinner placed conveniently near is helpful when spots or drippings must be removed before covering a surface.

11. The brush should be cleaned with a properly prepared thinner as a solvent after a lacquering job has been completed. A cheaper brush-cleaning liquid than lacquer-thinner can be made from denatured alcohol and acetone mixed half and half.

12. No sandpapering between coats of lacquer is necessary unless the surface has become roughened and must be leveled or smoothed. Under varnish, however, it is advisable to sand the last coat of lacquer, because varnish adheres better to a sanded surface than to one that has a high gloss.

13. Only one coat of some brands of lacquer can be applied smoothly over a surface when a brush is used. The solvents in lacquer are so powerful that they are apt to soften an undercoat of lacquer, and the friction of the brush is often sufficient to cause roughness and undesirable brush-marks. If proper undercoats are used one coat of lacquer applied with a brush will usually make a good finish. Brushing-lacquer generally has more ‘‘body’’ than spraying-lacquer.

If more than one coat of lacquer must be applied, the finisher should allow the first coat at least one or two days to harden before the second coat is brushed on, or the later coats may be sprayed over the surfaces with an air-gun after from 3 to 24 hours. Some manufacturers have suggested that lacquer should have one hour for drying between coats. Experience has shown, however, that a much longer period for hardening is preferable. Several coats of some brands of lacquers, especially those containing ethylene glycol solvents, can be applied successfully by flowing the new films over the surfaces quickly and carefully with soft lacquer-brushes.

14. While lacquer sets very quickly, it should be given sufficient time for hardening between coats and before rubbing. The best results are obtained by allowing coats of lacquer to dry 48 hours before rubbing is attempted.

255. Spraying Lacquer with an Air-Gun.—A large proportion of the lacquer-finishes applied in factories on furniture and automobiles is sprayed on with an air-gun. Great speed is necessary in the application of lacquers, and this can be secured by the use of an air-gun which spreads a film of lacquer very evenly and smoothly over large surfaces.

Amateur finishers in school and home sometimes spray lacquer with a small sheet-metal hand spraying equipment, or even with a garden spraying outfit, which is cheap and consists of a hand-pump and a closed container for the lacquer. There are also superior outfits on the market for school use which consist of a tank for compressed air, a hand-pump for supplying air-pressure, and an air-gun for mixing the air and the lacquer.

A good spraying-outfit for school use can be made by the use of a steel tank that will withstand high pressure, and an air-pump run by an electric motor, Fig. 19. The tank for the air should be equipped with a gage in order that the pressure of the air may be known and controlled. To complete the spraying equipment an air-gun must be secured, together with tubing to connect it with a valve on the tank. An equalizing valve which when placed on the outlet of the tank keeps an equal or constant pressure of air on the gun is a helpful and valuable part of the outfit, because too much air pressure on the gun causes a fine white dust to settle into the wet finish.

A satisfactory pressure for applying lacquer with an air-gun is about 45 to 50 pounds to the square inch. Higher pressure up to about 120 pounds can be used successfully if the adjusting-button is changed to cut down the amount of air that passes thru the spray-gun. Heavy fluids, such as lacquer-enamels, paint-enamels, heavy varnishes, fillers, and other thick liquid finishes, require high air-pressure, and a large opening in the tip or nozzle of the spraying-head thru which the finishing-material passes.

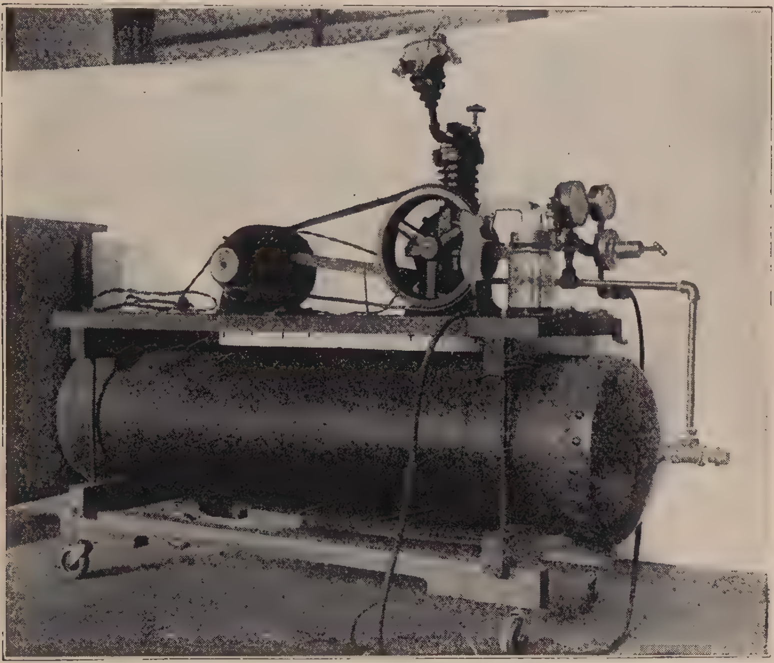


FIG. 19—SPRAYING-OUTFIT MADE IN A SCHOOL SHOP

This spraying-outfit was made in the shops of the Illinois State Normal University by A. W. Dragoo, assistant professor of industrial arts, who assembled the various units. The parts of the machine cost about $57.00.

The distance that the spray-gun is held from the surface which is being lacquered is usually about 6″ to 8″ with a 50-pound pressure, and about 12″ with a pressure of 75 to 100 pounds. The gun must be held close enough to the surface to deposit a thoroly wet coat rather than a mist of fine spots. Spraying-lacquer is light in body, and at best produces only a thin film. On this account it is wise to cover a surface with what seems to be a heavy, wet coat rather than with a very light one. If the lacquer is thin, care must be taken or too much liquid may be sprayed on upright or oblique surfaces. Coats that are too heavy will cause waves or sags and drops which run down and spoil the finish. A coat of lacquer thinner will often reduce and level such places if it is sprayed over the uneven finish before the film becomes too hard. The distance from the work to the spray-gun may vary somewhat, changing with the air-pressure, the size of the nozzle, and the thickness of the lacquer.

The nozzles on the air-gun which connect with the air-tank and the can or other container for the lacquer must receive very careful adjustments. If the air-nozzle of a cheap, double tube air-gun is too far away from the lacquer-nozzle, much more air will be used than is needed and a large amount of lacquer will be blown into vapor that fills the room instead of being used as a fine spray for coating a surface. The opening of the nozzle thru which the lacquer passes should be in direct line with the end of the air-tube and about as high as the center of the hole in the air-nozzle.

The distance from the point of the air-nozzle to the other nozzle in the double-tube type of gun may vary somewhat, but with thin lacquer, shellac, and varnish the two points when separated about 3/32″ will produce an excellent spray that is economical of both air and finishing material. Greater speed in spraying can be secured with the two points separated slightly more than the usual distance, and by placing a large-sized nozzle on the tube from the lacquer-container, but with such adjustments much more air is wasted, and a larger amount of the lacquer is blown into useless vapor, which sometimes has a very choking odor that is distressing to the people working in the finishing-room.

Various adjustments of the nozzles should be made until a satisfactory and economical spray is obtained from the air-gun. It is often advantageous to have several spray-heads or changeable tips or nozzles, because a smaller opening is needed for light stains, thin shellac, and diluted lacquer than for any of the heavier fluids used as finishes.

The troublesome fine white dust that accompanies the spraying of lacquer and settles where it is not wanted is often the result of using too high pressure, tho it may be caused by a bad adjustment of the nozzles of the spraying-gun, as already mentioned. An even pressure of about 45 to 50 pounds to the square inch, as indicated by the gage on the tank, should be used for many kinds of work instead of higher pressure which seems to vaporize the lacquer rather than to turn it into a wet spray.

The amount of dust from the air-gun spray can be greatly reduced by proper adjustments of the nozzles on the gun, and the use of a suitable pressure of air. A canopy or spraying-booth placed in the proper position to cover an article which is being sprayed reduces the amount of dust that can settle on horizontal surfaces. It is often wise to spray vertical surfaces first when lacquering a table or similar pieces, and then to wipe the top free from dust with a ''tack-rag'' just before the finish is applied to the top and other horizontal areas. The finished articles will dry with less dust from the spray if removed to another room as soon as possible after the lacquering process is completed.

Warning. Lacquer dust is very inflammable; therefore, in schools, all lacquer spraying should be done out-of-doors or in a booth only.

256. Drying of Lacquers.—Films made from lacquer set very quickly—in a very few seconds—and dry rapidly by evaporation, and not by oxidation, as is the case of oil-varnishes which dry partly by evaporation in losing their solvents and then by slow oxidation of the oils contained. Because many of the solvents that are constituents of lacquers are very volatile and the lacquers themselves contain no drying-oils, usually, there is a very remarkable speed in the setting and drying of nitrocellulose finishes. The present-day lacquers have more body or solid content than some of the earlier mixtures, and form thicker films which must be given more time for proper drying than was required for the earlier compounds of this type.

Experienced users of lacquers prefer to allow about 24 hours between coats, especially with brushing-lacquers or undiluted spraying-lacquers. Undercoats of lacquer are very apt to soften and become rough when later coats of these mixtures with their powerful solvents are applied over them unless they are very hard as a result of thoro drying. Some lacquers are said to dry in an hour, others in about four hours, allowing three coats to be applied in a day. Lacquer finishes are smoother, however, if plenty of time is allowed for drying. Undercoats of brushing-lacquer are liable to be damaged by brushing on a fresh coat before the previous one has entirely hardened thruout the entire thickness of the film.

In coatings sprayed on with an air-gun, some parts are thicker than others, and these thick films must have sufficient time for proper hardening. The rate of drying of coats of lacquer can be speeded up somewhat by placing the freshly finished articles in a warm room, but the newly-spread film should be thoroly set at ordinary temperatures or pinholes may appear because of too rapid drying.

Whenever a rubbed finish is desired over several coats of lacquer, two or three days should be allowed for the drying of the last coat before the final rubbing and polishing. The length of time needed for the drying of films or coatings varies somewhat with the different brands of lacquer. The furniture factories which use lacquer often allow only five to twelve hours for drying before rubbing is done.

257. Sanding, Rubbing, and Polishing Lacquer-Films.—Sanding between coats of lacquer is sometimes necessary if for any reason the surface is rough or has other defects that will interfere with the final smooth finish. Sanding can be done with a very fine grade of "Wetordry" sandpaper, used wet, preferably No. 4/0 to No. 6/0. Curved surfaces can be smoothed with very fine steel wool. It is not important to sand between the various coats of lacquer in order to secure proper adhesion, because a new nitrocellulose film will stick tight to an undercoat. If the finisher wishes to apply a coat of varnish over a lacquer-film, it is always wise to sand between coats, because varnish always adheres more satisfactorily to a sanded than to an unsanded surface. The sanding of lacquered surfaces is rather slow work, however, because a coating of this material is exceptionally hard. It is this unusual hardness that prevents the finish from being easily scratched or marred and is, on the whole, one of the good qualities of lacquer.

Rubbing and polishing improve the effect of a lacquered surface just about as much as these same operations soften and beautify a varnished surface. The procedure is very similar in the two cases. Lacquer-films can be smoothed or leveled slightly with wet water-proof sandpaper of a very fine grade, such as No. 6/0 or No. 8/0, before the rubbing process with pumice-stone is begun. Special sandpaper, which should always be used wet, such as automobile sandpaper Nos. 280, 320, and 400, are superior to other abrasives for sanding lacquered surfaces.

Lacquer-coatings or films must be thoroly solidified before any sanding or rubbing is attempted. Altho the surface of a film of lacquer seems to be perfectly dry after a few hours, the coating seldom fully hardens so that it is in proper condition for rubbing under 24 hours, and it is usually wise to allow not less than two or three days for the evaporation of the solvents, in order that the lacquer may not have any soft spots where too thick a coating was applied. Some manufacturers recommend that at least four days be allowed for drying after the application of the last coat, especially on three-coat jobs where only one coat is applied each day.

Very fine pumice-stone should be used for rubbing. A finisher can do a lacquer rubbing-job successfully with either the water or the oil process. Very fine pumice-stone is preferable, especially for rubbing with water. Coarse pumice-stone is liable to scratch a surface, and leave a grayish residue of pumice-stone in the abrasions left by the grit or cutting material. The rubbing should be done lengthwise of the grain, using a felt pad, and proceeding as in rubbing a varnished article. A rubbed surface should always be cleaned with a rag dampened with benzine or other similar liquid which is not a good solvent for lacquers.

Polishing a lacquered finish which has been rubbed produces a finer luster. Polishing can be done by a method similar to that used on varnish. Rottenstone and water are often rubbed over a lacquered surface, and a fine gloss is obtained with a mechanical buffer or a fine polishing-pad.

258. Flat Lacquers and Waxed Lacquer-Finishes.—It has been discovered that lacquers can be "flatted" or dulled in the manufacturing process by a method somewhat similar to that used in making flat varnishes. The addition of aluminum stearate to the lacquer in compounding it dulls the gloss of the film made from it, and gives it much the appearance of flat-varnish finishes. In use, one should always apply flat lacquers over flat lacquers, because gloss-lacquer undercoats are apt to show thru in spots.

Very attractive wax-finishes may be made over surfaces that have been covered with coats of ordinary gloss lacquer. The foundation or undercoats for wax may be a coat of shellac, sanded, and covered with one or two coats of lacquer. Before applying the wax, however, it should be remembered that oil rubbing with fine pumice-stone will produce a surface that is smooth and properly prepared to receive a high polish. Two undercoats of lacquer are greatly superior to two coats of shellac; because lacquer-coatings do not scratch easily or deeply; because they are much more water-proof than shellac, which can be washed off in cleaning with an alkali soap in water; and because of the fact that lacquer films do not print or become sticky in hot weather and, in general, are very heat resisting.

259. Mixture of Shellac and Lacquer.—An excellent water-proof shellac can be made by preparing a mixture of about one part of lacquer with three or four parts of shellac-varnish. Various proportions and strengths of the two ingredients can be used. The best results are obtained by pouring the lacquer into the container first, and then slowly adding the shellac-varnish, gradually blending the two by thoro stirring.

Water-proof shellac is an excellent finish for many purposes, and can be applied with a brush or with a spray-gun. Mixtures of shellac and lacquer do not keep well, and are not often sold on the market for this reason. They will remain in good condition in a liquid mixture for several days, but must always be thoroly stirred before use, because the two ingredients—lacquer and shellac—seem to separate.

A mixture of shellac and lacquer should be treated almost like shellac-varnish in storing in glass in order to prevent its darkening. It can be applied with a brush about as easily as shellac, and produces a fine soft, lustrous finish which is very attractive and possesses many desirable qualities.

Water-proof shellac is far more water-resistant than ordinary shellac-varnish. It can often be used to advantage under varnish or lacquer as a substitute for shellac, which is unsuitable as an undercoat for articles which are to be kept in damp places.

If a shellac-varnish contains shellac-wax, it may cause trouble because films made with lacquer and such a shellac-varnish may not dry properly. It is usual, however, to remove most of the shellac-wax from the shellac-gum in the manufacturing process; consequently the good brands of shellac-varnish contain very little wax, and this small per cent can very largely be removed by filtering out all insoluble matter from the liquid shellac.[5]

---

[5] See Section 144, "Lac-Gum," p. 169.

REFERENCES—CHAPTER XVI

LACQUER-FINISHES AND LACQUERING TECHNIC

American Paint Journal Company (St. Louis, Mo.), *A Lacquer Catechism.*

Wayne R. Fuller, "When and How to Use Lacquers," Science and Invention, Vol. II, No. 7, April, 1928, p. 1.

The Glidden Company (Cleveland, Ohio), *The Finishing of Wood with No. 35 Wood-Lacquer.*

R. A. McGee and A. G. Brown, *Instruction Units in Wood-Finishing,* Unit No. 5, "To Apply a Lacquer-Finish," pp. 36-39.

A. B. Pattou and C. L. Vaughn, *Furniture, Furniture-Finishing, Decoration, and Patching,* "Lacquering," pp. 202-4, 266; "Oriental Lacquering," pp. 350-3.

Glen H. Pickard, *Lacquers* (American Paint Journal Company, St. Louis, Mo.).

Walter K. Schmidt, "Casein Sealer Boon to Finishers," Furniture Manufacture Magazine, Vol. XXXVII, No. 2, February, 1929, pp. 47, 48, 88.

F. N. Vanderwalker, *Automobile Painting,* Chapter XV, "Lacquers and Pyroxylin Enamels," by Harold V. Cook, pp. 200-6.

F. N. Vanderwalker, "How Can the Ordinary Painter Apply Lacquer Successfully With a Brush?" American Paint Journal (St. Louis), August 15, 1927, and Reprint Circular No. 24.

F. N. Vanderwalker, *Wood-Finishing, Plain and Decorative,* "Lacquers," pp. 231-7.

The Zapon Co., *Zapon Lacquer-Finishes for Furniture* (Stamford, Conn.).

Ralph G. Waring, "Modern Lacquer Materials and Their Application," Industrial-Arts Magazine, Vol. XVI, No. 4, April, 1927, pp. 134-7.

CHAPTER XVII

PAINT AND PAINTING

260. Brief History of Paint and Painting.—The Bible tells us in the sixth chapter of Genesis that Noah was directed to build an ark of gopher-wood, and that it was to be covered with pitch both within and without. Doubtless the pitch which is mentioned was some kind of paint that was then well-known and commonly employed as a protective covering even before Noah's time.

Paintings that go back to prehistoric times have been found on the walls of sealed caves in France, Italy, and Spain. These paintings are supposed to have been made several thousand years ago and in some cases are in three colors—red, black, and yellow.

It is thought that painting had become a dignified art in Egypt as early as 3500 B. C. Numerous earthy colors were manufactured and used at that date. Lampblack was known and was employed by painters as a black paint. The white pigment of the Egyptians was probably made from chalk, and was similar to the whiting which we use for making calcimine and oil-putty.

Some of the early historians have mentioned that Egyptian and Cretan artists of about 1500 B. C. had a great variety of colors. These ancient pigments probably were quite similar to those of the present day.

It is also of interest to know that at about 1000 B. C. the Egyptians began to protect paintings on palaces, tombs, and mummy-cases with varnish. Many samples of these varnished paintings have been preserved to us thru being buried under the dry sands of the edge of the Sahara desert, and kept away from the disintegrating effects of atmosphere and rot-destroying fungi which usually soon ruin wood and other materials over which paint is applied.

Paintings which give us a good idea of the paints of Roman times of about the beginning of the Christian era have lately been discovered thru the recent excavations of the ruins of the old buried city, Pompeii.

There is much evidence to indicate that linseed-oil and many colors similar to those of the present day were known and used in times of great antiquity. Progress in paint-making has been slow. Empirical knowledge has accumulated thru many ages and has been handed down to later generations. The researches of the chemists of the past half century have, however, brought many changes and improvements in the paint-making industry.

THE FUNCTIONS OF PAINTS

The chief functions of paints are: (1) obscuration and decoration; (2) preservation of material; (3) sanitation and cleanliness; and (4) improved lighting-effects.

261. Obscuration and Decoration.—The first function of paints is probably obscuration, or the covering of an unattractive surface with an opaque finishing-material which will fill up small openings, cover defects, and produce a more level surface. Hiding the surface of the material by opaque paint pigments often produces pleasing tone or color effects that are new, bright, and attractive, and which generally add a decorative touch that appeals to the esthetic sense.

262. Preservation of Materials.—Wood, iron, and other materials can be protected by paint, and thereby preserved from the destructive action of the elements, chemical disintegration, or the growth of fungi. Paint protects various materials, especially wood and iron, from the snow and hail of winter, from rains, sand, and dust, and saves the surface from weathering. Iron on bridges and sheet-iron or tin, so-called, can be made to last many times as long, if kept properly painted. Iron window-screen wire will last many years if kept well-painted, but it will rust and go to pieces in a short time if it is not protected from the elements which cause oxidation or rusting. Properly-seasoned wood, especially that which has been kiln-dried, when properly painted usually lasts a long time because the surface is protected from the elements, particularly rain, and it is far more difficult for rot-fungi to get into the cells and start their destructive action.[1] Some paints for outside use contain creosote-oil which preserves wood because it destroys rot-fungi.[2]

263. Sanitation and Cleanliness. — Most surfaces are cleaned and made reasonably smooth preceding the application of paint. Paint materials are largely or entirely made by passing thru heat treatments of various kinds and are therefore reasonably germ-proof when they are applied. Paints are said to have antiseptic qualities of their own, especially when they contain turpentine. The most important sanitary qualities of paint are a result of its forming an impervious coating over wood and other materials; consequently dirt and germs are kept from penetrating painted objects. Surfaces that are painted with gloss paints in oil can be washed many times and kept much cleaner than can unfinished surfaces.

264. Improved Lighting-Effects.—Paints can be used to secure soft and soothing lighting-effects. The decorator varies the colors and general tone to suit conditions of location with respect to natural light and general color-schemes. Dark rooms can be made lighter by the use of paints of the lightest tints and of the lightest colors if possible. The artificial lighting-effects of halls and rooms, as well as the outside of buildings, can be varied and made attractive by the color-schemes employed. The artists who planned the lighting-effects of all of the recent World's Fairs considered the color-effects of the lights upon the walls and various parts of the buildings and also upon the green plants and shrubs, and the flowers that were placed near the walls, the walks, and the driveways.

---

[1] See A. C. Newell, *Wood and Lumber*, pp. 154-157.

[2] Ibid., pp. 161, 162.

COMPOSITION OF PAINTS

The principal ingredients employed in compounding paints are known as pigments, vehicles, thinners, and driers. Paints are mechanical mixtures rather than chemical combinations or compounds.

265. Pigments—Pigments give obscuration to paints, and may be composed of materials which add color or roughness, and binding qualities as well as covering power. It is therefore proper to divide pigments into three great classes as follows: (1) white or body pigments, the function of which is to give opacity and body to the paint; (2) colored pigments, which are used largely for their color-giving properties, tho some have good hiding power, density, and permanency; and (3) extenders, which in some cases increase the durability of the paint, reduce its price, and add roughness which is advantageous especially in undercoats. The extenders are white pigments but are not body or covering pigments.

White pigments used in paints may be divided into two distinct classes: (1) pigments which remain in an opaque condition after being mixed with drying-oils, and (2) inert pigments that offer very little hiding power or obscuration as a body material in paints after being incorporated into mixtures containing drying-oils, but which add durability and remain chemically inactive. Inert pigments usually retain their opacity whenever water instead of a drying-oil, such as linseed-oil, is used as the vehicle. The principal white pigments which remain opaque in mixtures with drying-oils are white lead, including both the basic carbonate of lead and the sulphate of lead, zinc oxide, zinc lead, lithophone, titanium oxides, antimonious oxide, which is used as a substitute for white lead in France, and tin oxide which is sometimes employed in making opal glass.

The white pigments which are largely inert, and show little or no chemical reaction with drying-oils which are acid in nature, are calcium carbonate or whiting, which is apt to saponify unless there is white lead in a mixture with the drying-oil, gypsum, barytes, China clay, silica, talc or French chalk, and asbestine. The inert pigments are often called "extenders," because their hiding power or opacity when mixed with oil is very small. The "extenders" are not considered as adulterants, pure and simple, by some manufacturers of prepared paints, who claim that small percentages give protective qualities and improve durability of the more active opaque pigments.

The colored pigments are sometimes subdivided into four classes: (1) colors containing lead, (2) colors from iron, (3) carbon colors, and (4) organic colors. Some of the well-known pigments in the lead group are red lead, chrome yellow or lead chromate, and its various modifications called chrome orange and chrome green. The iron colors have been known for ages; the oxides being contained in such earth colors as Turkey red, Venetian red, Indian red, red ocher, yellow ochers, which contain ferric oxide (Fe_2O_3) in varying amounts; the black oxide of iron (Fe_3O_4); the umbers, which contain usually more than 36 per cent of iron oxide (Fe_2O_3); and the siennas which contain from about 55 to 79 per cent of ferric oxide (Fe_2O_3).[3] Prussian blue, sometimes called Chinese blue, also contains an iron salt of a very different kind. The slow-drying carbon-black pigments are known as graphite or plumbago, lampblack, carbon black, charcoal black, and ivory or bone black. The organic colors are numerous and diverse in origin. They may be derived from animal, vegetable, or chemical sources.[4]

266. Vehicles.—Vehicles for paints are of three distinct classes: drying-oils, varnishes, and water. Vehicles really have two functions in paints: (1) if they be drying-oils or varnishes, they act as binders which on drying cement the particles of the pigments together and to the surface, and often penetrate into porous or absorbent materials, and on hardening form anchorages for the film of paint; and (2) they form a fluid that helps to carry the powdered pigments to the places where they are wanted by adding brushing qualities not possible with dry substances. Where water is the vehicle a certain amount of cementing or binding quality should be given to the paint thru the addition of glue to the mixture.

---

[3] J. Gauld Bearn, *The Chemistry of Paints, Pigments, and Varnishes,* pp. 122, 123.

[4] See Chapter VIII, "Dyes Useful as Stains," p. 92; and Chapter IX, "Coal-Tar Dyes and Their Use as Wood-Stains," p. 104.

The *drying-oils* used as paint vehicles are linseed-oil, which was practically the only oil commonly employed for the purpose until very recently; China-wood oil, also called tung-oil; perilla-oil, another fine drying-oil from the orient; walnut-oil, a pale oil used in artists' colors; soy-bean or soya-bean oil, a poor drying-oil which can be treated with driers; menhaden-oil, also called fish-oil, which is used on smokestacks, roofs, and on hot surfaces; and poppy-seed oil, which is a golden oil of slow-drying properties used in artists' paints.[5]

Flattening-oils are often made use of by painters who wish to mix their own flat wall-paints. Such flatting-oils can usually be obtained from paint-dealers. In composition flatting-oils often contain about one pound of alumina stearate to each 19 gallons of treated oils. The oils are frequently a mixture of China-wood oil chiefly with a small amount of linseed-oil. The drying-oils are given heat treatment with driers, such as lead acetate, at a high varnish-making temperature and are thinned down about one-half or more with wood-turpentine and benzine. Alumina-stearate jelly dissolved in turpentine can be stirred into a cold prepared drying-oil mixture consisting largely of China-wood oil which has been properly treated as described previously.

Gloss-varnishes are also sometimes incorporated into paints to add gloss and cementing qualities. Mixing-varnishes and grinding-liquids are sometimes incorporated into special prepared paints, such as floor-paints.[6] Varnish is most commonly added to paint for the purpose of hardening the film and increasing its durability and wearing qualities. Exterior paints do not often contain varnish. Enamels are mixtures of paint and varnish; but special varnishes are used in connection with special pigments, such as zinc oxide and lithophone.[7]

---

[5] See also "Drying-Oils in Varnishes," p. 231.

[6] See Winfield G. Scott, *Formulas and Processes for Manufacturing Paints, Oils, and Varnishes*, p. 3.

Water, the third vehicle for use in mixing paints, is employed in preparing water-color paints, such as calcimines and whitewashes.

267. Thinners.—The thinners used in paints are practically the same liquids which are employed for thinning oil-varnishes.[8] Turpentine is the best and the most commonly used thinner. Some of the coal-tar thinners, such as solvent naphtha and benzol, are sometimes employed; but they are too volatile for general use. The petroleum thinners, such as benzine, also called naphtha 54°, and the heavy naphtha 48°, are used in many prepared quick-drying paints. Benzine causes the paint to dry without gloss, and does not assist the oil in penetration into the pores of the wood as turpentine does. Petroleum thinners with the exception of benzine should not be added to paints, except in small amounts by expert manufacturers because they are non-drying liquids that are apt to cause tacky, soft paint-films that will not adhere well.

Kerosene should be avoided as a thinner, because paint mixed with this liquid nearly always proves unsatisfactory. White paint thinned with kerosene often turns yellow and rarely dries to proper hardness. It is true that benzine should not be used as a substitute for turpentine for exterior work; but, for inside use, it is satisfactory, and does not affect the kidneys nor produce other types of painter's ailments which are ascribed by many people to the use of turpentine.

The functions of *thinners* in paint are: (1) to reduce the thickness of the mixture to such a degree that it has proper flowing qualities when applied with a brush; (2) to increase the penetrating qualities of the paint, and enable it to enter deeper into the material over which it is being applied, thereby anchoring the coating more firmly to the surface and preventing scaling or peeling off after the film has set or hardened; and (3) to deaden the gloss of paints or to add flatness.

---

[7] Chapter XII, "Enamels and Enameling," p. 192.

[8] See also "Varnish-Thinners or Volatile-Oil Solvents," p. 236.

268. Driers.—The driers used in paints to accelerate the oxidation or drying-process, are similar to or exactly the same as the driers used in oil-varnishes.[9] The driers prepared by manufacturers for use as oxidation agents are of two distinct classes: one called an oil-drier, and the other a japan-drier.

The so-called oil-driers contain linseed-oil or tung-oil which has been cooked with metallic drying-salts from lead or manganese, or from both. A very concentrated oil-drier, sometimes called crusher's drier, is made thru heat treatment of linseed-oil with 15 to 20 times as much of the metallic oxides of lead and manganese as is ordinarily placed in linseed-oil in manufacturing what is commonly called boiled oil.[10] These oil-driers should contain no rosin, and do not resemble varnishes. They are very powerful in action, and should be used in small quantities because too large amounts in paints retard drying.

The japan-driers are more like rosin-varnishes, with an increased amount of lead and manganese drying salts cooked into them. They contain a varnish-gum, such as rosin, with lime to neutralize too great acidity, together with driers such as red lead and manganese dioxide, linseed-oil properly prepared, and thinners, such as turpentine and benzine 54°. The heat treatments used in making japans are similar to those generally employed in cooking varnishes.

269. White Lead—The most valuable of all the paint-pigments during the past 200 years or more has always been white lead. This ‘‘veteran’’ of the paint industry is often called lead carbonate. It is not a pure carbonate, however, but is what might be called a hydrated lead carbonate. In manufacture, white lead is made from three essential materials: metallic lead, acetic acid (the active portion of vinegar), and carbonic acid gas. The chemical formula usually given for white lead is $2PbCO_3Pb(OH)_2$. The exact amount of the lead hydrate varies somewhat if the action of the carbonic acid is unusually prolonged. In this case more than the usual amount of the hydrate is changed into carbonate.

---

[9] See also Section 189, "Driers and Their Functions in Oils, Varnishes, and Japans," p. 240.

[10] See S. W. Stratton, *Paint and Varnish*, Circular No. 69, U. S. Bureau of Standards. Department of Commerce, p. 11.

Various processes are in use for manufacturing white lead. The ‘‘Old Dutch Process,’’ which is said to have been old about the middle of the seventeenth century, was used in Holland. This method of producing white lead is a very good one, but it is slow and expensive.

The Dutch process is based on a reaction of metallic lead and dilute acetic acid in moist air which contains carbon dioxide. The lead is cast in the form of grids called buckles, which in the United States are about 5″ in diameter and 3/16″ thick. The buckles are pierced, leaving a plate with a large number of holes resembling a grate. Stamped sheet-metal buckles are not practical, because the metallic-lead particles become too compact to permit proper corrosion. It is for this reason that buckles for white lead making are always of cast lead.

Earthen corroding-pots are used as containers for the buckles, which are piled horizontally one on top of the other filling the pot, Fig. 20. The earthen pots are glazed on the inside, and are about 6″ in diameter and 10″ high. The lower 3″ of the pot is smaller in diameter, forming a well for the dilute acetic acid, and leaving a ledge just above the small lower cylinder upon which the buckles can rest without being immersed in the acid.

Lead corroding by the ‘‘Old Dutch Process,’’ the method most commonly used in the United States, is done by placing layers of pots in stacks, called stack-rooms. Special buildings for this purpose contain a number of stack-rooms which may be of various sizes, but frequently they are about 20 feet by 40 feet on the floor, and perhaps 20 feet to 30 feet in height.

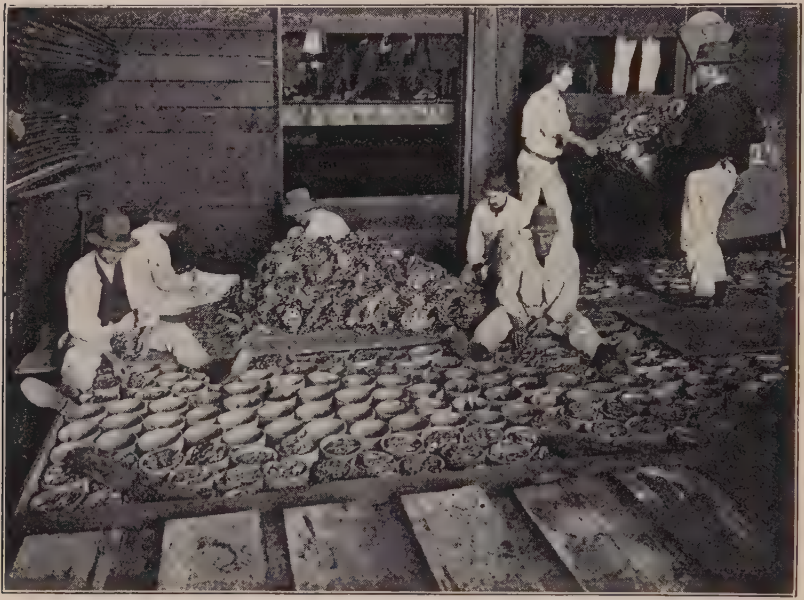


Fig. 20—"Setting" Lead Buckles—Ready for Corrosion Stacks.
Courtesy of the Sherwin-Williams Co.

The process of corroding the lead buckles into white lead is simple; but it takes a long time, and the chemical action is not obvious without considering all of the factors. The first operation in filling an empty stack is to place a layer of spent tan-bark to a depth of 10″ to 20″ on the floor. A layer which is made up of even rows of pots containing buckles of lead is placed on top of the tan-bark leaving a banking of about 18″ of bark around the edge. An opening for an air-space leading to a central flue or chimney, is left for ventilation. The flue is temporary and is built of boards, or a ventilating-pipe is placed in the middle of the room.

The pots are carefully covered with boards, and on top a new layer of tan-bark is filled in to a depth of about 15″ in thickness. The entire room is filled with alternate layers of pots which contain the lead buckles and about a pint of 2½% or 3% acetic acid or acidulated water. The weak acid is sprayed or run into the pots thru a hose connected to a tank of acid. The acid is put into the pots just before the layer of boards is placed over the top of the earthen containers.

Chemical action changes the metallic lead buckles in the pots into white lead. The change is very slow and requires about 120 days. Some kind of fermentation takes place in the tan-bark, and heat is generated which raises the whole mass to a temperature of from 160° F. (71.1° C.) to 180° F. (82.2° C.). Carbonic-acid gas is produced by the decay or fermentation of the organic matter of which the tan-bark is composed. The heat which is generated slowly volatilizes the acetic acid that is contained in the pots.

Chemists think that the lead is changed into a basic lead acetate by the action of the acetic acid on the lead. The lead acetate is then changed to a lead carbonate by the carbon dioxide (CO_2) or carbonic-acid gas which is abundantly produced by the hot fermenting tan-bark. The carbonate is not a pure carbonate, however, the final result being a material called white lead, a somewhat variable mixture usually containing about two parts of carbonate of lead and one part of hydrate of lead.

As already stated, the formula for white lead is usually given as $2PbCO_3Pb(OH)_2$. In case of prolonged action of the carbonic-acid gas more of the hydrate of lead is changed into the carbonate, and the formula for the product might be three parts of the carbonate to one of hydrate. A pure carbonate of lead which is not blended with lead hydrate does not make a good paint, because when an uncombined lead carbonate is mixed with linseed-oil a mixture is produced that does not have good covering capacity tho it is opaque.

The action of the hydrate of lead in linseed-oil is, however, very different. The hydrate of lead and drying-oil combine to form a sort of transparent varnish which has little power of obscuration. Neither carbonate of lead and a drying-oil, nor hydrate of lead in such an oil when used alone, will make a good paint. Lead carbonate and lead hydrate when mixed together in the form of white lead, however, make an excellent covering material which has excellent adhesive qualities obtained from the lead hydrate and oil mixture, and also good obscuration which is derived from the lead carbonate and oil. It is for these reasons that the manufacturers of white lead wish to produce a hydrated carbonate of lead from the buckles in the pots.

After allowing the chemical action on the lead buckles to continue for about three to four months, the stacks are unloaded. Great care is taken to prevent the tan-bark from getting into the pots and mixing with the white grids or buckles that have been corroded from pure metallic lead. Sometimes parts of the buckles will not be corroded into the white formation; consequently this metallic portion is removed by mechanical means, and the chunks or powdered portions are washed, ground, and sifted, and finally are made into powdered white lead.

It is very important that the white lead be ground to a proper degree of fineness. The grinding is done in water-mills between horizontal revolving flat stones, Fig. 21. After grinding, a thoro washing is necessary to remove the acid which is left by the corroding process. All tan-bark must be removed, and also any coarse, improperly ground particles of corroded lead. The last processes are pulverizing and grinding the white lead with linseed-oil to make what is often called *keg lead.*

There have been a number of other processes for making white lead some of which are still in use. Very good white lead is made in about twelve days in the United States by the Carter proces. The chemical action in all of the processes is somewhat similar to that of the "Old Dutch Process," but the procedures vary widely. The composition of white lead made by different processes varies considerably, and this means varying quality and color.

Basic *lead sulphate* is used to some extent in paints. Lead sulphate is non-poisonous, while the corroded carbonate of lead is poisonous to some extent. Lead sulphate has one advantage owing to the fact that it does not darken with sulphur gases while paint made from lead carbonate does darken seriously at times.

FIG. 21—GRINDING PIGMENTS IN A PAINT MILL.
Courtesy of the Sherwin-Williams Co.

Lead sulphate (formula $PbSO_4$) is made by adding sulphuric acid to acetate of lead in a dilute solution. The sulphate of lead is whiter than the carbonate and is non-poisonous, but it has poor covering-power, and requires more oil in grinding into paste than does the carbonate of lead. The sulphate of lead makes a paint that is thought to be superior to ordinary white lead for painting steel structures.

Sublimed white lead is similar to lead sulphate, but contains from five to ten per cent of zinc oxide which remains with the lead sulphate in the process of manufacture.

Zinc lead is similar to sublimed lead, but contains equal parts of lead sulphate and zinc oxide.

The hydrated lead carbonate or white lead can be obtained in the form of powder, or more commonly in a paste form which contains about 8 per cent of raw linseed-oil.

270. Properties and Uses of White Lead.—The most important of all the white paint-pigments during the past two centuries has been white lead in a form similar to that made by the "Old Dutch Process." Practically all of the highest grades of paints of today contain a high per cent of white lead. This is true especially in paints manufactured for exterior use. White lead is one of the most opaque of the durable white pigments, and forms very stable mixtures in combination with the commonly used drying-oils, thinners, colors, and driers.

The most serious objection to white lead as a paint-pigment is that it is apt to lose its adhesion and gradually turn to powder. This powder will disappear, or "chalk off" in the language of the painter. Colored pigments used with white lead seem to retard its tendency to turn to powder when it is used as a last coat for outside work. Up-to-date painters often use from 10 to 15 per cent or more of zinc oxide with white lead for the finishing coat in order to obtain greater hardness and lasting qualities, and to avoid the danger of having the paint come off in powder after a time of exposure to the weather.

271. Zinc White.—The most valuable of all of the white pigments of modern origin is zinc white or zinc oxide. It certainly ranks just below white lead and above other white pigments, such as lithophone and titanox. Zinc oxide is manufactured in enormous quantities for use as a paint-pigment in England and in various European countries and also in the United States.

The chemical composition of zinc white is represented by the formula, ZnO. The oxide is usually ground in linseed-oil, in the proportion of approximately 17 or 18 per cent of oil to 82 or 83 per cent of the pigment in order to make a paste. Zinc white is insoluble in water. It is permanent, and is used in large quantities for inside work, especially in enamels where it is the best of all pigments. As a pigment in paint, zinc white is less opaque than white lead. It is superior to white lead in one respect, however, because it does not turn to powder and dust off when exposed to the weather. It is very hard and brittle in a film, and may scale off or check. It should not be used in paints intended for priming-coats, but from 10 to 15 per cent of the zinc-pigment may be used to advantage in a last coat for outside painting.

272. Lithopone.—Many flat wall-paints are manufactured in part at least from a new white pigment called lithopone. Chemically speaking we should call lithopone a compound of barium sulphate and zinc sulphide.[11] The chemical formula for lithopone is $BaSO_4 + ZnS$ with the addition, very often, of about one per cent of ZnO, zinc oxide.

Lithopone has greater power of obscuration than any other white paint-pigment, and is non-poisonous which makes it useful for toy-painting by children. It is used extensively for inside flat wall-finishes or for painting ceilings. It is sometimes used in paint-enamels and other finishes for inside use. It does not seem to have very high resistance to weather, and is not suitable for outside use. It is a very white and dense pigment, which is valuable in the linoleum industry and in the vulcanization of rubber.

The cost of lithopone has recently been less than one-half of that of white lead. For outside painting it lasts only about a year as it turns to powder and rubs off. It is satisfactory, however, for use on the inside of buildings where a cheap flat paint is needed.

Flat undercoat paint-pigments for use under enamels are sometimes made of about 91 per cent of lithopone and nine per cent of zinc oxide. The liquid portion of such an undercoat often consists of about ten per cent of linseed-oil together with varnish and mineral spirits.

---

[11] See also Section 275, "Barytes or Barium Sulphate," p. 355.

In grinding lithopone into a stiff paste about twelve per cent of oil is required.

Large amounts of lithopone are used as the chief body-pigment in many cheap paints for inside walls, especially.

273. Titanox and Titanium Oxide. — Paint-manufacturers are now placing another new white pigment in some of their prepared paints. In the United States it often is known under its trade name, *titanox*. It is composed of about 25 per cent of titanium white or titanium dioxide (TiO_2), with 75 per cent of what is called artificial barium sulphate $BaSO_4$, which in this form is also referred to as *blanc fixe*. The titanium oxide is precipitated on the *blanc fixe* which is of a very fine grain because it is a precipitated barium sulphate instead of the ordinary kind manufactured by grinding natural barytes rock.

Titanox is non-poisonous and is a pigment of unusual power of obscuration which is said to be nearly twice as great as that of white lead. The pure titanium oxide has about two to three times the opacity of white lead. Paints made from titanox are exceptionally durable and hold their color. They are rather soft, however, and apt to gather and hold particles of dust. When titanox is mixed with from 10 to 25 per cent of zinc white, which dries out very hard, the trouble is overcome and the paint is very satisfactory. Titanox is a very valuable pigment to use with other paints. Its cost on the market has recently been somewhat less than that of white lead, but more than that of zinc oxide.

Titanox is a valuable pigment of a very white color. It should not be considered as an adulterant when found in paints. Manufacturers of prepared paints often use titanox in high-grade paints because they believe it will add some good qualities that no other pigment can give to the paint. Pure titanox paint does not weather well when used unmixed with other paints because of its tendency to turn to powder and "chalk off."

Titanium oxide, the essential constituent of titanox, is too expensive to use as an independent paint-material, and is unsatisfactory when so used. Titanox pigment is superior to many of the white paint-pigments in opacity, in gloss and smoothness of surface in a paint film, in its easy mixing characteristics, and in its freedom from discoloration when attacked by hydrogen sulphide which affects white lead paints in chemical laboratories, about gas-works, and near oil-fields.

274. Antimony Oxide or White Antimony — Another new white pigment which has recently been used in France on account of its non-poisonous qualities is antimonious oxide (Sb_2O_3). The pigment makes a good white paste with about ten per cent of oil.

Paints made from white antimony are like those produced from titanium oxide in that they dry slowly and do not become very hard unless other pigments are included in the mixture.

275. Barytes or Barium Sulphate.—The most important of the inert pigments or paint "extenders" is barytes ($BaSO_4$). There are really two forms of barium sulphate: (1) precipitated barytes, which is called *blanc fixe,* an artificial white pigment having a very fine texture; and (2) a natural, rather coarse powder, which is ground from a crystalline mineral known as baryte or heavy spar. The ground mineral powder is usually called barytes, and is less expensive than *blanc fixe.*

Of all of the pigments barytes requires the smallest amount of oil for making it into a paste. Barytes is chemically stable, and causes no chemical reaction when mixed with other materials in paints.

The characteristic of inertness and its lack of color are qualities that make the *blanc fixe* form of barium sulphite a base for making chemical colors such as various "lakes." Green colors can be "reduced" or "extended" with little loss of purity of tone because *blanc fixe* has very little opacity.

Barytes is not ordinarily added to paints by painters, but is often used as a cheap adulterant by manufacturers for extending white zinc and white lead paints. In limited quantities barytes is thought to contribute to the durability of a paint film and to have a tendency to bleach the linseed-oil. Very little oil (6 to 9 per cent) is needed in making barytes into a paste, and little or no extra oil is required when this pigment is added to mixtures of other pigments and oil in paste form. This means that a paint made with barytes as an added pigment has more body to the same amount of oil which, of course, is ordinarily desirable. The crystalline structure of the fine particles of barytes presents in a painted surface a very good undercoat quality and makes repainting satisfactory. Barytes is also thought to reduce shrinking and contraction of paint-films as they become old.

Barium sulphate is mixed with zinc sulphide in lithopone in the proportion of 71 to 72 per cent of the barium salt to 28 or 29 per cent of the zinc salt. The barium sulphate in lithopone is of the artificial or chemical type. Lithopone is made as a result of a chemical reaction resulting from adding a solution of barium sulphide to an equivalent solution formed of zinc sulphate. A precipitate of fine barium sulphate and zinc sulphide is formed which is filtered and calcined, and later ground to powder.

276. Whiting or Calcium Carbonate.—Whiting is sometimes employed as an oil paint "extender," but it is used chiefly in making calcimine which is a water-mixed paint. It is also the body ingredient of oil-putty, which consists of a thick paste of linseed-oil with whiting. An excellent putty may be made by mixing whiting in the dry form into a paste of white lead and oil.[12]

Whiting is made from natural chalk, and is calcium carbonate ($CaCO_3$). Chalk is ground by a process of levigation or grinding, several different grades of whiting being prepared which depend upon such qualities as whiteness and fineness. The best grades are called "Paris white" and "gilders white," and it is these two grades which are used as "extenders" in oil-paints. These grades of whiting are said to neutralize the acidity of paint mixtures and help to hold the pigment in suspension. The lower grade of whiting, which is a commercial whiting and is given no special name, is the form that is used in calcimine and for manufacturing putty.

---

[12] See also Section 312, "Putty and Puttying," p. 389.

Whiting is sometimes placed in oil-paints made from white lead, and the combination has proved to be very durable. Whiting requires about 18 per cent of oil to grind it into a paste, and is considered to be a very bulky pigment. The color of whiting is very white. When whiting is ground in oil it does not have much opacity or covering-power, but mixtures of whiting and water possess very good body or power of obscuration.

Plaster of Paris is similar to whiting but is a sulphate of lime. Plaster of Paris is manufactured by heating gypsum ($CaSO_4 + 2H_2O$) until it loses part of its water of crystallization, which takes place at a temperature of about 180° to 190° C. Plaster of Paris is used as a cement, for the repair of plaster cracks, and for making casts, but it is not a paint-pigment proper.

277. Magnesium Silicate or Asbestine.—In a list of paint "extenders" we should not omit asbestine, which is about as valuable in the paint manufacturing industry as barytes. Asbestine is valuable in paints, especially on account of its structure which is fibrous. This elongated shape of the particles helps in binding paint-films together mechanically just as iron rods add strength to reinforced concrete. The light fluffy nature of asbestine aids in holding paint-pigments in solution. With asbestine in a mixture, the pigments have less tendency to settle to the bottom. When very heavy pigments, such as white lead or basic lead sulphate, are incorporated into paints a light fluffy "extender,'' such as asbestine, is very valuable. Cheap paints containing barytes can be kept in solution when asbestine is added to help to float the other ''extenders'' which have a tendency to settle.

The cost of asbestine is low because it is made out of a cheap material, asbestos. In chemical composition it resembles China Clay, which it has largely displaced as a paint ''extender.'' China Clay is, however, an hydrated silicate of alumina, while asbestine is a silicate of magnesium.

Asbestine is also known on the market under such names as talc and French chalk.

278. Silica or Silex.—Silicon dioxide (SiO_2) is another ''extender,'' which is usually made by crushing quartz rock and grinding it into a fine powder. Other materials such as chert, flint, and sand are sometimes employed as rough material for use in the manufacture of silica or silex.[13]

Silex is the most important body material known for filling the pores of wood, and is widely employed in wood-fillers for this purpose. Silex and silica, which are similar substances, are also used in small quantities to give ''tooth'' or roughness to undercoat paints. The slight roughness added by silex is thought to give a greater hiding power to a second coat of paint because more paint will stick to a rough than to a smooth surface without causing running, sagging, or wrinkling of the film. Some ready-mixed paints include about two and one-half per cent of silex or silica because these substances add ''tooth'' to the paint. They do not directly increase the covering-power of paints because they are almost transparent when mixed with linseed-oil. They do add to the obscuration of a film of paint, however, because they make it possible for a surface to hold a thicker coat of paint.

Several paint-pigments when mixed with linseed-oil are in a smooth and soapy condition, and the addition of a small amount of crystalline material that is somewhat rough and elongated rather than round, tends to add a binder to the film, and improve its surface for repainting.

---

[13] See S. W. Stratton, *Paint and Varnish*, Circular No. 69, U. S. Bureau of Standards, Department of Commerce, p. 35.

BLACK PIGMENTS

The best and most commonly used of the black pigments are lampblack, carbon or gas black, bone black, ivory black, charcoal black, and graphite.

279. Lampblack.—Lampblack is a grayish black pigment which is bulky and very permanent. It is composed of almost pure carbon. Lampblack is soot deposited by burning such substances as mineral oils, or even fats, resins or resinous woods, under conditions which furnish incomplete combustion because of lack of plenty of air or of the cooling action of some substance, such as cold porcelain, which may be placed in the flame. Lampblack in oil dries very slowly, but its drying qualities may be improved by the addition of driers or other colors. It is often used for exterior painting because of its durability. It has a flatting effect when used in black paints and enamels.

280. Carbon Black.—Carbon or gas black is an American black manufactured by a process similar to one of the methods used in producing lampblack. It is made largely from natural-gas flames which strike revolving drums and leave a deposit, called gas black. It produces a color that is far blacker than that obtained from lampblack. Carbon black is preferable to lampblack as a solid black, because it does not produce so dull and grayish a tone. Carbon black has much greater obscuring or hiding power than is possessed by ivory black. It is largely used in printers' inks and in paints. In durability for exterior use it is nearly equal to lampblack.

281. Bone or Ivory Black.—Some years ago real ivory black was made by burning ivory. Today the best grades of ivory black may be made by heating ivory chips and cuttings, but the price of a real ivory black is practically prohibitive. Teeth and hard bones are at present used for making the best grades of ivory black. The name, bone black, is given to a black produced from bones from glue factories which are heated or burned in retorts. Ammonia and bone-oil are saved by some process thru distillation. The bone charcoal which is left as a residue is ground and produces the bone black of commerce.

The terms coach black, drop black, jet black, bone black, and ivory black mean practically the same thing in the United States.

Ivory or drop black is sold to the paint trade in a paste form, which means that the powder is properly ground in oil. Automobile- and carriage-painters sometimes obtain this same black ground in japan or varnish.

The color of ivory or drop black is denser even than that of carbon black. Ivory black has considerably greater opacity than lampblack. Ivory black often seems to have a blue-black tinge. Prussian blue in small quantities is sometimes mixed with drop black to modify the color or change its tone slightly.

The amount of oil required for grinding ivory or drop black into a paste is less than that needed in grinding lampblack.

282. Charcoal Black.—Charcoal black is produced from vegetable matter by a method similar to that used in manufacturing ivory or bone black. Charcoal is made by burning such materials as grapevine cuttings, twigs from trees, plum- and peach-stones, cocoanut-shells, or waste from cork, and a black is produced that is used chiefly in water-colors for artists.

283. Graphite. — Graphite, also called black lead or plumbago, is a natural mineral form of carbon which is mined as are other ores. An artifiical graphite is manufactured from molten cast iron and charcoal. Large quantities of graphite are sometimes found in iron-smelting furnaces.

Natural graphite was known to man from times of great antiquity. Its color is unattractive unless changed in hue by the addition of some other pigment. For this reason it has not been extensively used until recently.

In composition graphite is often nearly 90 per cent carbon. It contains two or three per cent of volatile matter and several per cent of ash. At one time it was thought to contain lead; hence the name, black lead, was given to it.

Mixed graphite-paints of the present day contain graphite as the chief pigment, but about ten per cent of whiting or a small amount of silica may be added, and the color may be changed with lampblack, or some other black, and red lead. A boiled linseed-oil vehicle is used, with a cheap thinner, such as naphtha 48°.

Graphite paints are especially valued for covering machinery and ironwork which is exposed to the weather, because these paints are not affected by exposure to outdoor air, smoke, gases, or destructive climatic changes. Undercoats of red lead are often used under graphite paints on iron roofs and other exposed ironwork. Graphite paints are unusually permanent. They are usually sold in colors, such as red, green, brown, being changed from their natural hue by the addition of other coloring-matter, especially the yellow and red oxides of iron.

RED PIGMENTS

The most numerous and important of all of the color-giving pigments are the red pigments. They are, in general, rather cheap, durable, and possess good power of obscuration. Some of the red pigments are earth colors, or natural red oxides of such metals as iron, lead, and mercury, while other reds are artificial or manufactured.

284. Venetian Red.—At one time Venetian red was obtained from a natural earth which contained a ferric oxide; but, at present, this fine red is almost entirely produced artificially. There are various qualities of Venetian red on the market, some kinds being cheap and fading, while the best grades are very durable when carefully ground with linseed-oil. The cheap Venetian reds are suitable for roof-painting, and for use on barns and box-cars. The best grades of Venetian red can be mixed with any of the other pigments and produce bright, attractive, permanent combinations which have good body, especially when made with gypsum as a base or extender. Gypsum is known chemically as a hydrated calcium sulphate. All of the water is removed from the gypsum by heating it to about 200° C. It is this burnt or dead calcium sulphate from gypsum that is used in Venetian red as an "extender."

The Venetian reds sold on the market are composed of an iron oxide (Fe_3O_4) which is a product of calcination of some such substance as ferrous sulphate with slaked lime. Venetian red is really a mixture of ferric oxide, called the sesquioxide, with burnt calcium sulphate ($CaSO_4$). The United States government specifications for Venetian red require that at least 40 per cent of the pigment shall be sesquioxide of iron, which is the real source of color in the pigment.

285. Indian Red.—Red oxides of iron that formerly came from India gave us the name of this pigment. This natural red ocher was calcined in such a manner as to drive off the moisture and produce the desired shade of red. At present most of the Indian red of commerce is manufactured by burning or roasting ferrous sulphate, commonly called green vitriol or copperas ($FeSO_4$), until a material is produced which in the best grades is about 95 per cent ferric oxide (Fe_2O_3).

Indian red is a pigment of unusual permanence in sunlight and mixes well with other colors. It is very opaque and may be "extended" to some extent by inert pigments, such as whiting, barytes, and gypsum, and yet cover a surface very well. It is inexpensive and reliable as a color, and is very widely used.

Various tints of Indian red can be obtained by modifying the heat treatment or by the addition of salt during the calcining process which tends to change the red to more of a purple hue. The characteristic color of Indian red is, however, a brick red.

286. Tuscan Red.—An alizarin lake is used to modify the ordinary Indian red and produce a crimson-toned color called Tuscan red. An account of its ability to withstand outdoor exposure Tuscan red is used in paints for machinery and implements, passenger-cars, and sometimes on steam-pipes and radiators. It is a very strong color which is unusually permanent, and can be ''extended'' with gypsum, whiting, or barytes.

287. Red Lead.—This brilliant scarlet pigment is old in history, and was known and used by the ancient Egyptians. In composition it consists of 85 per cent or more of true red lead (Pb_3O_4), and the balance largely of lead monoxide, a drier called litharge (PbO).

Red lead, also called minium, is a powerful drier, and its reactions are often such that it can not be mixed with paints which are to stand longer than 24 hours before use. High grade red leads which are very fine and 98 per cent pure are now made that do not harden with an oil in a container and can be put up in paste form.

The high price of red lead tends to reduce its use, but for over 100 years it has been considered the best possible material to employ for the priming-coat on steel and iron as a protection from corrosion. The running-gears of wagons and machines are often primed with red lead.

A red-lead priming-coat may be made from a paste of red-lead powder and a drying-oil, together with asbestine and barytes ''extenders,'' and a soy-bean oil-vehicle, together with a cheap thinner such as heavy naphtha 48°. Red lead will not grind into a fine paste with linseed-oil on account of its crystalline structure. It is a common practice for painters to mix red-lead powder with linseed-oil just before the paint is to be applied. Red lead is not mixed into white-lead paints. The color is not very satisfactory because it usually fades after a time.

288. Other Red Pigments.—Vermilion, scarlet lake, and carmine are red pigments which are used to a small extent.

Vermilion is a beautiful bluish-scarlet pigment that is not very permanent. The English vermilion is a mercuric sulphide (HgS) which is very heavy and settles to the bottom when mixed with oil. It was formerly used extensively, but at present it is expensive, and little valued except by coach-painters for the railroads. The American vermilion is a lead chromate which is fairly permanent to light. It is, however, blackened by sulphides. Vermilion of the American type is used in paints for iron and steel, and is said to be superior to red lead. It is too expensive for general or extended use, however.

Scarlet lake and *carmine* are beautiful red colors made from cochineal. These colors, largely used as stains, are quite transparent, and often fugitive in light. They are employed to some extent in paints to modify the colors of other pigments, but they lack opacity when used alone.

The lakes in general are formed by precipitating a dye, usually a coal-tar dye, upon an inorganic base, such as *blanc fixe,* which is an artificial barytes or barium sulphate ($BaSO_4$). If the dyes are permanent then the lakes are not fugitive; and, of course, if dyes are used that are not light-proof, the lakes which are made from them will fade. As a class the lakes are fugitive, especially such delicate colors as rose pine and rose lake.

289. Orange-Red Pigment.—Burnt sienna is a beautiful rather transparent pigment largely used in stains. It is made by burning or calcining raw sienna at a low temperature. Raw sienna is a natural earth color, the best grades of which come from Italy. Painters use the transparent form of burnt sienna quite extensively for graining. Burnt sienna is a mixture of materials, such as silica (SiO_2) about 13 to 20 per cent, ferric oxide (Fe_2O_3) about 65 to 80 per cent, aluminum oxide 1½ to 5¼ per cent, together with small quantities of manganese dioxide and calcium sulphate. House-painters' burnt sienna is quite opaque, and is used for tinting paints. Burnt sienna makes a good cherry color. It can be changed to a mahogany by the addition of rose pink or some other similar color.

Burnt sienna can be obtained on the market in the form of a dry powder or in a paste containing the pigment ground in oil. For use in tinting oil-paints the paste ground in oil should be used.

YELLOW PIGMENTS

The yellow pigments most commonly used for coloring paints are: yellow ocher, raw sienna, the chrome yellows, Naples yellow, zinc and barium chromate yellow, and a few artists' colors such as cadmium yellow, King's yellow, aureolin or cobalt yellow, and Indian yellow.

290. Yellow Ocher and Golden Ocher.—Natural yellow ochers are earth colors that receive their coloring-matter from a certain hydrated iron oxide ($2Fe_2O_3.3H_2O$). Ochers are dug out of the earth in England, France, Spain, the United States of America, and other parts of the world.

A good yellow ocher should have a clear yellow color and contain 20 per cent or more of sesquioxide of iron (Fe_2O_3), and not more than about five per cent of calcium compounds. Ochers vary considerably, depending on where they are obtained and whether or not they have been adulterated. A good French ocher should contain 20 per cent or more of ferric oxide (Fe_2O_3), a silica base often 52 per cent to 54 per cent of the whole weight, alumina (Al_2O_3) to the extent of 12 to 14 per cent, and small amounts of other substances.

The French ochers are said to have a silicate base, and are superior; while the American ochers have an alumina or clay base, and are much inferior. Our American ochers tint well; but their clay base absorbs water, and this moisture is apt to cause scaling and blistering of the paint after it is spread. Ochers should not be used in full strength for priming-coats, because they may cause the paint to scale or peel off after a time. If ochers of good grade are compounded with white lead and are finely ground, they may be used in priming-coats. Ochers are principally employed by painters in preparing or mixing cream or buff paints for exterior house-painting.

Golden ocher is manufactured by adding chrome yellow to an ordinary ocher. Golden ocher has a brighter yellow tone than has yellow ocher at least for a time, but this brilliance may finally be lost with the fading of the chrome yellow which is usually less permanent than is yellow ocher.

291. Chrome Yellow.—On account of their covering power, good body, and high chroma or brilliancy of color, the most valuable of all the yellow pigments are the chrome yellows. In tone they vary from the palest yellow to a rather red hue known as Persian red. The chrome yellows also vary in composition and are sold under such names as Primrose Chrome, Canary, Light or Lemon Chrome, Light Medium Chrome, Middle or Medium Chrome, Light Orange, and Orange Chrome.

The medium chrome yellow is a basic chromate of lead ($PbCrO_4Pb(OH)_2$) with a small amount of carbonate of sulphate of lead. The pale chromes contain also either carbonate or sulphate of lead. These substances are precipitated with the chromate of lead and thus form a perfect mixture. Orange chrome consists of a mixture of the basic chromate of lead with the normal chromate of lead ($PbCrO_4$).

Chrome yellows are slowly affected by atmospheric conditions, but are ranked as fairly durable colors. Pigments, such as ultramarine blue, which contain sulphur in the form of a sulphide should not be mixed with chrome yellows because sulphides darken such yellows until they become almost black. The chrome yellows should not be placed in mixtures which include such ingredients as silicates, lime, soda, or other substances with an alkaline reaction, because there will be a chemical reaction, and the yellow will be changed in hue to an orange or red. Chrome yellows are less permanent than yellow ocher, but they are so much superior to ocher in brilliancy that they are used for many purposes and are generally satisfactory. Decorators find many uses for chrome yellow pigments, but house-painters do not use them extensively. The medium chrome yellow is the color most likely to be chosen for outdoor use.

The tinting power of pure chrome yellow is much greater than that of yellow ocher. Owing to its great strength or brilliance of hue a chrome yellow can be adulterated considerably without very great danger of detection by the ordinary painter.

292. Raw Sienna.—The city of Sienna in Italy or its neighborhood furnishes the best raw and burnt siennas that are known. The siennas are earth colors that are very permanent and are old in history, having been used during the glorious days of Rome.

Raw sienna looks like yellow ocher, but it has a slightly deeper yellowish tone. It is a rather transparent color that is useful in oil-stains and for graining. Its transparency makes raw sienna less valuable for a body color to give obscuration; but, when mixed with white, good cream tints are obtained which are stronger in hue than are similar mixtures of white and yellow ocher.

Raw sienna receives its color from ferric oxide (Fe_2O_3) which should be included in the earthy matter to an amount of not less than 50 per cent, and it often may exceed 70 per cent. The other constituents of raw sienna are largely silica (SiO_2) and alumina (Al_2O_3).

293. Other Yellows.—*Naples yellow* is a very opaque pigment which contains oxides of antimony and lead. The color is permanent but rather expensive, and is little used except by decorators and artists. It is considered more satisfactory as an oil-color than as a water-color, because it lacks proper transparency for use in water-color painting.

Cadmium yellow is a sulphide of cadmium (CdS). It can be used to tint white lead without danger of injurious effects or changes as a result of the action of sulphuretted hydrogen. Cadmium yellows are not poisonous; they have good opacity and are permanent. They are little used, however, except by artists because they are high in price.

The color known to artists as *Aurora Yellow* is quite similar in composition to cadmium yellow, but its color effect is slightly different.

BLUE PIGMENTS

The most important and extensively used blue pigments of the present day are ultramarine blue and Prussian blue. The copper blues which were formerly used have almost disappeared from the market because they lack good covering-power and are fugitive. Cobalt blue is an excellent and very permanent color, but expensive.

294. Ultramarine Blue.—At one time a pretty blue stone called the lapis lazuli was used in the manufacture of the finest of all the blues. During the past century, however, similar blue pigments have been manufactured by chemical processes. This color was used by artists during the middle ages, and has been known generally as ultramarine blue. Colors which are sold to artists under such names as New Blue, French Blue, and Permanent Blue are modifications of ultramarine blue.

Various methods have been used in the manufacture of ultramarine blue which is chemically a very complex compound containing alumina, soda, silicates, sulphur, and other substances.

Ultramarine blue is a very valuable pigment, because it is fast to light, is not changed by sulphurous gases, and can be manufactured in various shades and modifications of hue. The variations have a range from reddish tones to almost violet. Its opacity is good compared with Prussian blue. It can be used with various mediums such as oils, japans, varnishes, and with water. Calciminers and water-color artists prefer it, in general, to most of the other blues. It is not recommended for use with chrome yellow or white lead, however, because the sulphur in its composition has a tendency to react with the lead and darken the color. With zinc white it mixes satisfactorily and safely. Ultramarine blue is often mixed with other pigments, but it is rather too expensive to be used extensively by house-painters. It is, however, quite often used with zinc-white pigments which are not affected by it except for the change in color.

295. Prussian Blue.—A valuable color which is much used by printers and painters because of its brilliancy of tone is generally called Prussian blue. It is sometimes known as Paris blue. A slightly modified but very similar color is sold as Antwerp blue. Chinese blue is the same in composition as Prussian blue, but it produces a color that is much paler in tone, and has a slight cast of violet or green.

Prussian blue is of rather recent origin. It is extensively used by artists for painting in both oil and water-color. It is a very strong color, which makes its use economical; as only very small amounts of it are needed to tint or change the tone of other colors. Prussian blue is a transparent color, however, which is moderately permanent in light. Sunlight modifies Prussian blue, slowly changing it to a greenish tone. The color is often ranked as a rather fugitive color, and it is not satisfactory for exterior painting. Prussian blue is apt to give a dark greenish or a blackish-blue effect that is not as attractive in tone as that produced by ultramarine blue.

Alkalies seem to destroy Prussian-blue colors, turning them brown. This makes the use of Prussian blue over newly plastered walls impossible because the color will be destroyed or changed in spots. This blue is extensively used, however, by implement-manufacturers in dipping-paints, for covering parts of polished steel, especially.

In one manufacturing process Prussian blue is obtained by oxidizing the blue precipitate which is thrown down by the addition of an iron (ferric) salt to a solution containing ferrocyanide of potassium. Chemists give Prussian blue the formula, $KFe_2(Fe_2Cy_{12})$.

296. Cobalt Blues.—Several kinds of so-called cobalt blues are sold on the market. The cheaper kinds are usually nothing but ultramarine blue toned down or reduced in brilliancy by the addition of zinc white.

The genuine cobalt blue is an oxide of cobalt together with an oxide of aluminum. The pigment is prepared by a process of precipitation from a caustic soda solution of alumina by a cobalt chloride solution. This type of cobalt blue is an unusually permanent color which is much too expensive for ordinary painting, and is used almost entirely by artists for fine painting, and to a limited extent for tinting paper for bank-notes. It has very limited use in the pottery trades and for tinting pale enamels.

GREEN PIGMENTS

There are really two classes of green inorganic pigments—green earth colors, and manufactured green pigments. We might also include a third class, the lakes, which are usually made from coal-tar colors on an inert material, such as *blanc fixe,* an artificial barytes ($BaSO_4$). The most commonly used of all the greens is called chrome green or Brunswick green.

297. The Earth Greens.—The earth greens are rather dull colors, which are known by such names as Terra Verte and Veronese Green. These pigments are ranked as permanent, but they lack body and good covering power; consequently they have largely been replaced by other greens. They make an excellent base material, however, for use in manufacturing certain "lakes," such as Malachite Green, Brilliant Green, and Methylene Blue.

Chemically speaking, the green earths are a magnesium ferrous silicated aluminum oxide. The earths or clays are sometimes called augites.

298. Chrome or Brunswick Green.—The green pigment which is in greatest demand on the market is made by mixing Prussian Blue or Chinese Blue with Chrome Yellow, and is called Chrome or Brunswick Green. It is made up in various shades of green which vary from almost yellow to nearly blue in tone. Chrome greens lack durability, being composed of materials that are not very durable; but they are used extensively, because they possess great brilliancy of effect and have excellent covering power. The wagon and agricultural implement manufacturers are large users of chrome green, and they find it a satisfactory color because it holds its coloring power about as long as the paint lasts.

"Chemically pure" chrome greens are mixtures of the blue and yellow in full strength. Weaker and cheaper chrome greens are made by the use of such "extenders" as barytes or a silicate. Such materials may be used up to about 75 per cent of the mixture with only 25 per cent of color. These poorer grades are called "commercial" green in the paint market.

299. Other Green Pigments. — *Chrome Oxide Green* (Cr_2O_3) is the only true chrome green. It is a very permanent but rather dull color. Altho it is an excellent green pigment, it is too expensive for general use because of difficulties in the manufacture. It can be safely mixed with all other pigments, and is not affected by alkalies, acids, or heat.

Cobalt Green is an expensive, rather dull, and nonpoisonous pigment that is very permanent, but it is little used except by artists. It is manufactured thru a combination of a zinc salt, such as zinc oxide, with cobalt nitrate.

Viridian or *Emeraude Green,* is a good transparent green that is considered to be permanent, and for this reason it is much used by decorators. Sunlight and sulphuretted hydrogen gas do not affect it. Chemically, Viridian is an hydrated sesquioxide of chromium. It is a stable color which can be mixed safely with any of the other colors.

Permanent Green is similar to Viridian, but it is cheaper because diluted or "extended" with an alumina hydrate or some other cheap material.

BROWN PIGMENTS

There are only a few brown pigments that are worthy of consideration. The valuable browns of the present day are the raw and burnt umbers, and Vandyke brown—all of them earth colors. Sepia, a color much used by water-color artists, is of animal kingdom origin being manufactured from the "ink-bag" of the cuttlefish. Sepia is not a true pigment, but it is valued as a transparent color. The earth colors in the brown group were known and used by nations of great antiquity. The name umber came from the word Umbria, a province of Italy.

300. Raw Umber.—There are a number of grades of raw umber, since earth colors under that name are found in various places, such as England, France, Germany, and America, and they vary greatly in quality. The best umber is called Turkey umber because it is marketed thru Constantinople. The color comes from the island of Cyprus, and is not actually mined in Turkey.

Raw umber somewhat resembles the siennas and ochers, except that it contains considerably more of the manganese oxides, such as MnO_2 and Mn_3O_4. The raw umbers sometimes contain as much as 20 per cent of manganese oxides; and, in such cases they have strong drying qualities for oils that are used as vehicles in paints. The use of large amounts of umber in oil-paints may cause trouble because of the strong drying action of the manganese oxides contained in the umbers.

Raw umbers of good grade are fairly permanent or even almost entirely permanent in light. In opacity and staining power the umbers rank high.

Paints containing raw umber dry very quickly and become unusually hard. They also are thought to wear exceptionally well. In color, raw umbers have a range from a yellowish brown to a dark brown. The pigment works very smoothly and easily under a brush.

301. Burnt Umber.—In the preparation of burnt umber, the ordinary raw umber is roasted over a slow fire. The color of burnt umber is derived from its high content of Ferric oxide (Fe_2O_3). The other most important constituent of a good grade of Turkey burnt umber is manganese dioxide (MnO_2), which varies in quality, but which is commonly found in the pigment in amounts of about twelve per cent. Burnt umber may be used in limited quantities, and is valuable in paints and varnishes; on account of its high manganese dioxide content, it adds drying qualities as well as color to the mixtures.

Burnt umbers are more transparent than raw umbers, usually, and they acquire a darker, warmer reddish-brown color that is useful and much appreciated by painters. This brown pigment is used extensively in oil-stains, for graining, and as a glazing color.

302. Vandyke Brown.—This color is named after a celebrated Flemish portrait painter who is said to have used the pigment, which we call Vandyke brown, very effectively. The Vandyke browns resemble the umbers somewhat in composition, but are supposed to derive their coloring properties from bituminous, ferruginous, or carbonaceous earths that are found in Germany and Ireland, and also in some other countries. The Vandyke browns which are obtained from different countries vary greatly in composition. In general, they contain a very large amount of organic matter, with small amounts of iron and alumina compounds, and also some lime.

When Vandyke brown is ground in oil it is considered reasonably permanent. Ground or dissolved in water, it is less permanent in bright light. It is a much more transparent pigment than umber. It is, however, a favorite color with some water-color artists. Glazers and grainers use it to a considerable extent. Vandyke-brown pigment, ground in oil and thinned with turpentine, is often used as an oil-stain to imitate or represent walnut.

Vandyke brown when ground in linseed oil is a very poor drying pigment, and it should not be used without adding some manganese japan drier to the mixture.

An imitation Vandyke brown that is very permanent is sometimes made from drop black, burnt umber, and Prussian blue. These pigments are not as transparent as Vandyke brown; consequently they make a mixture of less transparency than the genuine color.

303. Metallic Pigments.—The demand for various metallic paints which are made from powders of bronze, aluminum, zinc, tin, copper, and gold, together with a proper varnish medium or some bronzing liquid as a vehicle has grown greatly during recent years. Metallic paints are highly decorative under proper conditions, and are valued on account of their anticorrosive qualities when they are used to cover metals such as radiators for steam and hot-water heating. Metallic paints are good conductors of heat.

The alloy for making an imitation gold bronze is made from copper and zinc. The reddish gold bronzes contain from 1 to 5.6 per cent of zinc, while the yellow or light gold bronzes may include from about 15 to 19 per cent of zinc in their composition. Bronze powder is made from thin sheets of the metal, which are ground into very fine particles. Various color-effects can be obtained in the metallic powders by heat treatments, as by heating in a paraffin bath; or new hues are produced by mixing certain coal-tar dyestuffs in the paints to secure the desired color. A painter can change the colors of bronzes by the addition of colors ground in japan. Colors ground in oil do not dry quickly nor mix well in lacquer.

White bronze is made of the metal, aluminum, by grinding it into fine powder.

About six pounds of bronzing powder to each gallon of bronzing liquid are generally used in gold bronze or common bronze powders. Much less aluminum powder can be used, because it is very light and more bulky. It is usual to mix only about 1½ to 2 pounds of the dry aluminum powder to the gallon of bronzing liquid. Sometimes bronze powders are measured instead of weighed for mixing. A tablespoonful of bronze powder to each pint of lacquer makes a bronze paint that covers satisfactorily.

The bronzing liquid may be a very heavy-bodied boiled linseed-oil. Rapid-drying bronzing liquids are sometimes made from mixtures of heat-treated linseed-oil and tung-oil, together with japan driers and benzine as a thinner.

For inside bronzing, decorators often thin a good grade of rubbing-varnish with turpentine, and add bronze powders until a paint of the proper brushing consistency is prepared. Spar-varnish may be substituted for rubbing-varnish whenever the bronze paint is to be used outdoors.

A quick-drying bronze paint can be prepared by using banana-oil, or preferably a good nitrocellulose lacquer, or even a mixture of brushing-lacquer and banana-oil, as a vehicle for holding the bronze powder in suspension in the paint and making it possible to spread it with a brush.[14]

304. Characteristics of Paint Ingredients.—Earlier in this Chapter it was pointed out that a paint consists of pigments, vehicles, driers, and thinners.[15] It should be remembered in mixing paints that a thinner such as turpentine adds penetrating properties, and makes the paint flow more easily over the surface. One part of turpentine will thin about twice as much paint-paste as one part of linseed-oil. It follows that, if turpentine be substituted in part for linseed-oil, there will be relatively more pigment in a paint-film. Turpentine, however, gives a flat effect to a paint if it is added in any considerable amount.

305. Pigment-Pastes.—Paint-pigments, such as the basic white-lead carbonate and zinc oxide, can be obtained in dry powder form, but they are very difficult materials to incorporate into a paint-mixture unless they have previously been ground in oil with proper machinery. For this reason paint-factories prepare lead carbonate and zinc oxide in paste form. A mixture of lead-pigment with oil in the form of a paste is called keg-lead.

A white-lead paste or keg-lead as it comes from the manufacturer is composed of eight pounds of pure raw linseed-oil to each 100 pounds of basic white-lead carbonate. This amount of materials will make a bulk of about 2.75 to

---

[14] See C. A. Kunou, *Manual of Gilding and Compo Work*, pp. 25, 119.

[15] See "Composition of Paints," p. 342.

2.85 gallons after mixing, and each gallon will weigh about 36 pounds. One should not confuse paint-pigment pastes with mixed paint because, in ready-to-use paints, pastes are thinned and driers are often added. In each 100 pounds of properly prepared white-lead paint, ready for use, there should be about 35 pounds of liquids to 65 pounds of pigment. For priming-coats and some other purposes thin paints which contain relatively less pigment are used.

In making a zinc-white paste, more oil relatively to the zinc pigment is required than in grinding white-lead carbonate and oil into a paste. The amount of raw linseed-oil commonly used in zinc-white paste varies from a minimum of about 14½ per cent to a maximum of 19 per cent. Most zinc-white pastes contain about 17 per cent of raw linseed-oil. The bulk of 100 pounds of zinc-white powder after it is ground with linseed-oil into a paste is approximately 4⅛ gallons.

A zinc-white paste is often made from 37.75 pounds of zinc oxide to one gallon of raw linseed-oil, which usually weighs slightly more than 7¾ pounds. This mixture produces about 1.83 gallons of paste which weighs about 24.8 pounds to the gallon. A prepared zinc-oxide paint of the proper consistency for use is made from a paste of zinc oxide together with raw linseed-oil and usually thinners and driers. Such a paint should contain about 54 pounds of zinc oxide and about 46 pounds of drying-oil to each 100 pounds of the mixture when it is ready for application.

White lead and zinc white are the only white pigments commonly sold on the market in the form of paste. The other white pigments, the white extenders, and some of the colored body pigments are sold only in powdered form. The painter will save himself trouble and loss of time if he buys his pigments ground in oil whenever it is possible. Dry colors are often rather coarse, and it is very difficult to mix them with oil by hand. The factories have special equipment for grinding pigments till the particles are very fine and then mechanically mixing oil with the pigments.

306. Paint-Mixing by a Painter.—Practical men have learned thru experience that there is a best procedure or method of putting the ingredients together when mixing paints. A brief statement of the approved steps in preparing a ready-to-use paint mixture may be of value to inexperienced users of paint. The usual procedure is as follows:

1. Select a drum or other container about twice as large as the bulk of the final mixture, and wet the inside with a small amount of linseed-oil.

2. Place the entire amount of one kind of pigment in the container. (Mix different pigments, such as white lead and zinc white, with the drying-oil in separate containers.)

3. Pour linseed-oil into the paste of lead or other pigment, adding only about one-half of a pint at a time.

4. Stir the paste with each new quantity of oil that is added, until the mixture is free from lumps or thick portions of paste. A wooden paddle of convenient size is commonly used for the stirring or mixing process. Add only enough oil to break up the paste thoroly at this time.

5. If other pigments, such as colors ground in oil, are to be added, they should be mixed into the pigment-and-oil mixture until the proper hue is secured. Color should be added slowly and cautiously, and test samples should be made.

6. The amount of drier indicated by the formula should next be stirred into the paint mixture. If boiled oil is substituted for raw oil, no drier is needed; and if used it will harm the paint.

7. Pour the remainder of linseed-oil into the paint-mixture a little at a time, carefully stirring and mixing the pigments with the oil. (Paint formulas vary greatly in the amount of oil suggested.)

8. The thinner, such as turpentine or mineral spirits, should next be stirred into the paint. Turpentine tends to "flat" paints, and should not be used in excess.

9. In order to remove coarse particles, it is wise to

strain the paint thru a fine screen wire. If the paint is to be used inside of a building, or if a very smooth surface is wanted, a final straining of the thoroly mixed paint thru a double cheese-cloth screen is advisable.

307. Formula for Mixing Paints.—

First Coat. (For use when three coats are required.)

FORMULA No. 1

A thin priming white paint for outside use on new wood.
Pigment—Hydrated lead carbonate (white lead), 100 pounds
Vehicle—Raw linseed-oil, 4 gallons
Thinner—Turpentine (gum turpentine preferred), 1 to 2 gallons
Drier—Japan-drier, or preferably oil-drier, 1 pint.

In bulk this mixture measures about 9 to 9⅛ gallons, if two gallons of turpentine are used.

Very sappy or resinous woods require a large amount of turpentine. Woods which easily absorb linseed-oil, such as yellow poplar, basswood, pine, and old weathered unpainted surfaces, require a priming-paint with much oil in it; while less absorbent woods, especially yellow pine, spruce, hemlock, bald cypress, and most hard woods, require less oil.

Too much drier in paint is harmful. The maximum amount of drier that should be used is 1 part of drier to 20 parts of raw linseed-oil. If boiled oil is substituted for raw oil in paint, no drier should usually be added. An oil-drier reduced with turpentine or benzine is considered superior to japan-drier by many experts. Oil-driers are very powerful and contain no rosin; and, in this respect, they are preferable to most japans which contain varnish gums, and often rosin which is cheap.

Second Coat. (When three coats are required.)

FORMULA No. 2

For an outside white paint for use on new wood.
Pigment—Hydrated lead carbonate (white lead), 100 pounds
Vehicle—Raw linseed-oil, 1½ to 2 gallons
Thinner—Turpentine, 1½ to 2 gallons
Drier—Japan-drier, 1 pint.

If 1½ gallons each of turpentine and raw linseed-oil are used, the bulk of the mixture should be about 6⅛ gallons. The covering-capacity of the 6⅛ gallons of paint should be about 3500 to 3600 square feet if it is properly spread with a brush.

For repainting outside on wood this formula is suitable for the first coat if 2 gallons each of raw linseed-oil and turpentine are used to give fluidity.

Third Coat. (When three coats are required.)

Formula No. 3

For an outside white paint for use on new wood.
Pigment—Hydrated lead carbonate (white lead), 100 pounds
Vehicle—Raw linseed-oil, 4 gallons
Thinner—Turpentine, 1 pint
Drier—Japan-drier, 1 pint.

The third coat for outside painting should contain a large amount of drying-oil, and very little turpentine, because the oil adds gloss to the paint, and increases the binder which holds the paint particles together.

This formula may also be used for the last coat in a two coat repainting job. When the paint is to be applied as a second coat for repainting, a heavier mixture containing only 3½ gallons of linseed-oil instead of 4 gallons is preferable.

Special Zinc and White Lead Paint.

Formula No. 4

For a last coat for outside use.	
Pigments, 65% by weight:	
Hydrated lead carbonate, white lead,	71 per cent
Zinc oxide (zinc white),	21
Magnesium silicate (asbestine),	8
Total pigments,	100 per cent
Liquids, 35% by weight:	
Vehicle—Raw linseed-oil,	91.0 per cent
Thinner—Turpentine or mineral spirits,	4.5
Drier—Japan-drier,	4.5
Total liquids,	100.0 per cent

Manufacturers of mixed paints recommend zinc white to the extent of 10 to 25 per cent of the total pigments of an outside paint that is to be used for a finishing-coat. The zinc white is added to prevent excessive weathering or powdering of the white lead, and to make a harder surface. In rainy regions or near the sea many painters substitute about 15 per cent of zinc white for white lead in a white-lead paint formula.

Asbestine is recommended in small amounts because it is fibrous, acts as a binder, and helps to keep the paint in solution while in the can because of its light fluffy nature.

Interior White Paint for Plastered Walls.

FORMULA NO. 5

For inside use for priming-coat.
Pigment—Hydrated Lead Carbonate (White Lead), 25 pounds
Vehicle—Boiled linseed-oil, 1¾ gallons
Thinner—Turpentine (Gum turpentine preferred), 1 quart.

The alkali in newly-plastered walls should be reduced or neutralized by the use of a zinc-sulphate solution before priming.[16]

Flat Interior White Paint for Plastered Walls.

FORMULA NO. 6

For second and third coats.
Pigment—Hydrated Lead Carbonate (White Lead), 25 pounds
Vehicle—Flatting-oil, 2 to 3 quarts.

FORMULA NO. 7

Another second coat of flat paint. (An alternative for Formula No. 6.)
Pigment—Hydrated Lead Carbonate (White Lead), 25 pounds
Vehicle—Raw linseed-oil, 1 pint
Thinner—Turpentine, 2 quarts
Drier—Pale japan-drier, ¼ pint.

FORMULA NO. 8

Another third coat flat wall paint. (An alternative for Formula No. 6.)
Pigment—Hydrated Carbonate of Lead (White Lead), 25 pounds
Vehicle—Pale enamel-varnish, ¼ pint
Thinner—Turpentine, 2 quarts
Drier—Pale japan-drier, ⅛ pint.

---

[16] See Section 311, "Priming," p. 387.

Interior Flat White Paint for Wood.

FORMULA NO. 9

For first coat.
Pigment—Hydrated Lead Carbonate (White Lead), 25 pounds
Vehicle—Raw linseed-oil, 3 quarts
Vehicle and thinner combined—Flatting-oil, 3 quarts
Drier—Pale japan-drier, ¼ pint.

FORMULA NO. 10

Flat white paint for second and third coats.
Pigment—Hydrated Lead Carbonate (White Lead), 25 pounds
Vehicle and thinner combined—Flatting-oil, 2 to 3 quarts.

Flat Enamel Undercoat Paint. (For inside use on wood especially.)

FORMULA NO. 11

A second-coat paint.

Pigments, 65% by weight:		
Lithophone,		91 per cent
Zinc oxide (zinc white),		9
Total pigments,		100 per cent
Liquids, 35% by weight:		
Vehicle—Linseed-oil,	10	
Pale enamel-varnish,	35	45 per cent
Thinner—Turpentine or mineral spirits,		55
Total liquids,		100 per cent

This undercoat paint may be used for a priming coat by the addition of the following to each gallon of paint:
Thinner—Turpentine, 1 pint
Vehicle—Raw Linseed-Oil, 1 pint.

Red-Lead Paints for Metal.

FORMULA NO. 12

For first or priming-coat. (Red-lead paints next to metal should contain no other pigment.)
Pigment—Dry red-lead powder, 25 pounds
Vehicle—Raw linseed-oil, 4¾
Boiled linseed-oil, 2⅜ 7⅛ pints
Thinner—Turpentine, up to ¼ pint per gallon, if required
Drier—Red lead is a drier; consequently no other drier is necessary.

Alternative Formula with Red-Lead Paste.

FORMULA NO. 13

Pigment—Red-lead paste (Red lead and oil), 25 pounds
Vehicle—Raw linseed-oil, 3⅓
Boiled linseed-oil, 1⅔ 5 pints
Thinner—Turpentine, up to ¼ pint per gallon of paint
Drier—None.

Brown Metal-Paint for Second and Third Coats.

FORMULA NO. 14

Pigment—Dry lead powder, 25 pounds
Vehicle—Linseed-oil, approximately 1/3 boiled and 2/3 raw; total, 4¾ quarts.
Coloring-pigment—Paste lampblack, 12 ounces to 6¾ pounds of the mixture
Thinner—Turpentine, small amount as required
Drier—None.

Priming-paints for woods that are hard and nonabsorbent should be thicker and contain less linseed-oil and turpentine than for porous soft woods. Woods which contain much resin, such as yellow pine, should be washed with turpentine. All knots and resinous places should be coated with shellac to prevent the exudation of gum, and then primed with a thin paint. Some experienced painters recommend the addition of a small amount of benzol to priming-paints which are to be used on resinous woods. For cypress especially, the priming-coat is more satisfactory if about ½ pint of benzol or toluol is added to each gallon of mixed paint. These solvents are very powerful, and seem to aid the priming-coat in penetrating more deeply into the cells of coniferous woods that are somewhat resinous.

Various colored white-lead paints can be used over red-lead priming-coats.

Red-lead paints can be changed in color by the addition of paste-pigments. Green paint is sometimes made by the addition of medium chrome green and Chinese blue in paste form until the proper color is obtained. Whenever colors are added, more linseed-oil must also be added, or the paint will be too heavy to spread well.

308. Mixing or Blending Colors.—It is very difficult to give dependable suggestions for mixing colors, because the pigments sold on the market vary somewhat in hue and color strength, even tho they are sold under familiar names. The following suggestions may prove helpful in mixing colors:

Black (Purplish).—Lampblack, 5 to 7 parts; tint with rose pink, about one part; and a touch of purple or violet.

Blue-black.—Ivory black, 13 parts; Prussian blue, about 1 part.

Blue (Light or Delft).—White lead and cobalt blue, with a slight quantity of black.

Blue (Sky).—Tint with cobalt blue, or equal parts of cobalt blue and Prussian blue. Ultramarine blue should not be used with white lead, but it may be used safely with zinc oxide.

Brass (Yellowish).—White lead, 20 parts; chrome yellow (light), 6 parts; and equal parts of raw and burnt umber, 1 part.

Bronze.—White lead, 9 to 11 parts; lemon chrome yellow, 4 parts; and raw umber, 4 to 5 parts.

Bronze (Green).—White lead, dark chrome green, and lampblack; or white lead, medium chrome green, ivory black, and a small amount of raw umber.

Brown (Golden).—White lead, 10 pounds; French yellow ocher or raw sienna, about 24 ounces; and burnt sienna, 8 ounces.

Brown (Warm).—White lead, 2 to 3 parts; Venetian red, 3 parts; yellow ocher, 3½ to 4 parts; and ivory black (with a touch of blue), 1 part.

Brown.—Indian red, 3 parts; yellow ocher, 1 part; and oil lampblack, 2 parts. Various browns can be obtained by changing the proportions. Venetian red may be substituted for Indian red, and burnt umber for the yellow ocher and lampblack.

Brown (Reddish).—Vandyke brown, 2 to 8 parts; and burnt sienna, about 1 part.

Brown.—Black and various reds, such as Venetian red, Indian red, burnt sienna, and vermilion.

Buff.—White lead, tinted with yellow ocher or raw sienna. For a warmer tone, a little middle chrome yellow may be added.

Citron or *Citrine.*—Orange, 4 parts; and chrome green, 1 part. Or lemon chrome yellow, about 5 parts, with raw umber, about 2 parts. Citron is a tertiary color containing yellow chiefly with smaller portions of red and blue.

Cream.—Tint white lead with yellow ocher and a touch of Venetian red; or white lead, yellow ocher, and a little vermilion.

Drab.—Various proportions of white lead, burnt and raw umber, and yellow ocher.

Drab.—White lead, 25 pounds; raw umber, about 1 pound; and, if necessary, French yellow ocher until the brown tone is grayed.

Gold.—Mix into white lead a gold made from a red such as vermilion, 1 part; and a golden ocher (or a mixture of yellows, including chrome yellow, yellow ocher, and raw sienna), about 5 parts.

Green.—Mix various yellows and blues.

Green (Yellowish).—Chrome yellow or lemon chrome yellow, 4 to 8 parts; Prussian blue, 1 part.

Green (Bluish).—Use equal parts of Prussian blue with a mixture of chrome yellows, such as lemon and middle chrome.

Gray.—Use the three primary colors red, yellow, and blue to neutralize each other. White lead and black make a dead or dull gray. Various grays can be made warmer by the addition of a little red or yellow. Cool grays may be obtained by the use of blue in the gray mixture.

Gray (Yellowish).—White lead, 25 pounds; French yellow ocher, 1 to 1½ pounds; Venetian red, ½ ounce; and lampblack, from ½ to ¾ ounce. Raw Turkey umber may be substituted for the Venetian red, and ivory black for the lampblack. For a warmer gray, a little burnt sienna or yellow ocher, or both, may be added.

Ivory.—White lead, 25 pounds; French yellow ocher, 1 pound; and Venetian red, up to ½ a pound.

Lavender.—White lead, 25 pounds; cobalt blue, about 12 ounces; and a red, such as madder lake, 4 ounces. Ultramarine blue is apt to darken with white lead. Prussian blue may be used instead of cobalt, but a less attractive color is produced.

Mahogany.—White lead, about 1 or 2 parts; orange chrome, 10 parts; and a red, such as burnt sienna, about 3 parts, depending upon the strength of red desired in the mahogany.

Olive.—Mix 4 parts of chrome green with 1 part of violet.

Orange.—White lead and chrome orange. The various chrome yellows, or yellow ocher, can be mixed with a red pigment in order to make an orange color.

Pink.—White lead with various reds, such as Indian red, rose madder, carmine lake, vermilion, and Venetian red, are ordinarily used in producing pink tones.

Purple.—Equal parts of white lead, Indian red, and Prussian blue. Black may be added to darken the shade. Other reds, such as carmine or crimson lake, may be substituted for Indian red.

Rose.—White lead with a little rose lake. Other reds such as vermilion, or even Turkey red, or crimson madder, are sometimes used.

Russet.—Mix 4 parts of orange with 1 part of violet, and tint the white pigment.

Slate.—The same as olive; or, mix white pigments with ivory black and Prussian blue in the proportion of about 3 to 1. Ultramarine blue is preferable to Prussian blue, except when white lead is used.

Stone.—Tint white pigments with yellows and browns, such as yellow ocher and raw umber. Burnt umber and Venetian red are also added sometimes in small quantities.

Tan.—White pigments may be tinted with brownish yellow, such as raw sienna. Touches of burnt umber, or vermilion and chrome yellow, are sometimes added.

Violet.—Use 4 or 5 parts of Ultramarine blue to one of red, such as crimson lake or carmine. For white-lead paints, substitute Prussian blue for Ultramarine blue.

Walnut.—Mix about 5 parts of burnt umber with 1 part of raw sienna; or substitute yellow ocher for the raw sienna, and add more brown.

309. Application of Paint.—A few suggestions about the use of paint may prove of value to the inexperienced painter.

Paint should not be applied during very wet or cold weather. In fact, wooden surfaces especially will not absorb the oils of paint properly if the pores and cell-walls of the material are even partly water-soaked. All painting should be done on dry material, or trouble of various kinds may follow.

Surfaces to be painted should be free from dust, dirt, plaster, and mortar. The surface should be smooth, but not necessarily hand planed, scraped, and sanded, after the fashion of articles that are to receive a varnish or lacquer finish.

Knots in all resinous woods should be given a coat or two of shellac to prevent resin from exuding thru the paint during hot weather.

Old painted surfaces generally require cleaning with a stiff steel-wire brush and a scraping-knife. It is often advisable to wash old surfaces with strong soapy water, or a solution of washing-soda made from about one-half pound of soda to each gallon of water. If the old paint is chipped off in spots, or is rough, the painter should use sandpaper of about the No. 1 size to smooth the defective spots. Sanding and brushing with a steel brush help in making a more level foundation for the new coats of paint.

310. Number of Coats of Paint.—It is necessary to apply three coats of paint in order to secure a properly covered, attractive surface that will endure outdoor weather conditions for a reasonable length of time. The first coat is usually called the priming-coat, the second the body-coat, and the third the finishing-coat. While three coats of paint are required on new work, repainting can usually be done satisfactorily with two coats. In repainting, the priming-coat is usually omitted, unless the old paint is practically all gone, and the wood or other material is weathered.

311. Priming.—The composition of the first coat of paint is important because it is the priming material which enters into the pores of wood or other substances and forms anchorages. It is the priming-coat that fills up the open cells in wood, and makes a foundation to which later films of paint will adhere.[17] Priming-paints which are to be used on cypress and yellow pine will penetrate these woods more satisfactorily if benzol, a powerful solvent for gums and oils, is used as part of the liquid. Cypress contains an oil, and yellow pine contains a resin, both of which are substances that prevent a satisfactory penetration of ordinary thin oil-paints. Benzol in paint reacts on the oils and resins of coniferous wood, and permits the paint to enter the cells and adhere to the wood. About two-thirds of a pint of benzol to each gallon of priming-paint produces a good penetrating-paint for use on cypress and yellow pine.

When benzol is added to first-coat paints in appreciable amounts, the linseed-oil and turpentine are reduced in about equal quantities; otherwise the paint would be too thin for most purposes. The benzol entirely evaporates in a short time, leaving a residue in the paint-film composed of pigments, drying-oil, and drier. The turpentine evaporates also, leaving only a slight residue of a varnishlike nature. Paints containing benzol should not be used for anything except priming, as this solvent may soften an undercoat if used in a second or third coat of paint.

Priming-coats are somewhat similar in composition and color to paints used for later coats, but they should be thinner. Formerly, priming-coats contained large amounts of yellow ocher, which is a cheap pigment. Ochers may, however, be used in moderate amounts for tinting lead paints. Yellow ocher easily absorbs moisture, and may cause paint to scale off. It may be used for tinting white lead, but it should not be employed in full strength as a body-pigment.

---

[17] See A. C. Newell, *Wood and Lumber*, pp. 28-43.

It is very important that the priming-coat of paint should be well brushed into the cells of wood. Paint should not be flowed on after the manner of applying lacquer or a final coat of varnish, but it should be worked well into the pores of wood, or small openings of other materials, with a brush in order to seal up the surface and make a foundation that will hold the pigments and oils of the body-coat on the surface. In painting, the brush should not be overloaded, because in this case paint may drop from the brush and do damage or make troublesome spots.

In applying paint, the experienced painter usually begins at the upper left-hand corner of vertical surfaces. If the wall of a house is being painted, a portion of the upper left-hand corner is painted, applying the paint with the grain. The workman covers as much of the wall as he can reach, then moves down, and paints another area below the first one. This operation is repeated until the left-hand edge is painted. The painter then goes to the top, and paints another area crosswise at the top, joining the second area to the first before the paint sets. Lower portions are then painted.

Inside walls of plaster, especially, are painted with up-and-down strokes of the brush, starting at the top and left-hand, and painting an area about three feet wide by two feet in height. Another similar area below the first one is then painted. After an area about three feet wide has been covered from top to bottom, a new start at the top is made, and another section is painted with up-and-down strokes.

On account of the alkaline nature of newly-plastered walls, it is advisable to apply a zinc-sulphate solution to the plaster before painting. This prepriming solution is made from about 3 or 4 pounds of zinc sulphate to a gallon of water. After this neutralizing coating has dried thoroly, an ordinary priming-paint may be applied. There will be little danger of having the paint peel off if the alkali of the plaster is properly neutralized by zinc sulphate.

312. Putty and Puttying.—After the priming-coat of paint is dry, the next process is puttying or filling nail-holes, grub- or worm-holes, all cracks, and other defects of any kind that damage the appearance of the surface.

Prepared putty in natural and dark colors can usually be obtained on the market. One of the best kinds of putty for exterior use can be made by mixing whiting with white lead in oil-paste in equal parts, and softening the mass, if necessary, with the proper amount of boiled or raw linseed-oil. Dry colors can also be mixed with the pigments whenever a putty of a special color is desired.

Some commercial grades of oil-putty are made from ordinary whiting and raw linseed-oil, 5½ pounds of whiting to one pound of oil being used. A putty made from whiting and linseed-oil, and containing no white lead, does not dry as hard as one containing more or less of the expensive lead-pigment as an ingredient, but it is preferred for setting glass and for some other purposes. The poorest grades of commercial putty often contain more or less marble-dust, and have little cohesion after they become dry.

Puttying should always be done after the priming-coat has become dry. If puttying is attempted before painting, the wood about the opening which contains the putty will absorb most of the oil which should oxidize in the putty itself and remain as a binder. Unless the oil remains in the putty, the particles of pigment have little cohesion, and the mass becomes friable and crumbles away.

Painters often use the thumb, or sometimes the fingers, for pressing putty into small openings, such as nail-holes. For large holes, a putty-knife is preferable. It is advisable to fill holes slightly more than full with putty, as there is some contraction during the drying out of the oil.

313. The Body-Coat, or Second Coat.—Additional coats of paint should never be applied until the undercoats are thoroly dry. The weather and the composition of the paint are variable factors, consequently it is impossible to give a definite time. The time of drying usually varies from two or three days to a week.

The second or body-coat should be of the same color as the finishing-coat, and somewhat thicker than the priming-coat. More turpentine and less oil are characteristics of body-coats as compared with priming-coats. A paint prepared in this way will adhere well to the priming-coat, and leave a flat surface that will receive a final coat of gloss paint if desired.

Brushing the paint on the surface as evenly as possible should be the aim in applying the body-coat.

314. The Third or Finishing-Coat.—A painter always aims to give the required color and good wearing qualities to the finishing-coat. For outside service this means that the final coat should be a gloss paint. In order to secure gloss, turpentine is reduced to a minimum in the formula. Linseed-oil replaces the turpentine, and adds its binding-qualities to the final surface of paint.

The third coat of paint should be applied as smoothly as possible, using the brush by the method already described for spreading the priming-coat.

House-painters usually apply the trimming-coat in connection with the finishing-coat. Two containers and two brushes at least are required in this case. The trimming-paint must be applied very carefully to avoid the possibility of having the two colors run into each other.

The painter should stir his paint frequently, and strain it if necessary to get rid of any chunks and coarse material which are apt to settle to the bottom, and which, if left in the paint, may get into the brush, and be carried to the surface.

Paints for floors and the inside trim of houses often contain a small amount of varnish which makes a harder surface. For outside use a good spar-varnish may be mixed with the paint.

315. Hints and Precautions for Painters.—White-lead paints are poisonous if taken into the stomach. Dust from lead paints, if inhaled, may get into the throat, and finally into the stomach. There is very little danger, however, if the painter washes his hands before eating, and avoids the use of tobacco while painting. Tobacco which is handled with hands partly smeared with paint is dangerous. There is such a thing as lead-poisoning, but it is entirely preventable, and is a very rare disease.[18]

Paints containing turpentine and benzine should not be placed near an open fire, as these solvents are very inflammable.

Ultramarine blue contains surplur, and should not be mixed with white lead or any other lead-pigment.

Turpentine is not recommended for use on the hands in removing paint. Linseed-oil will remove paint more easily, and then the hands can be washed with soap and water.

Benzine or kerosene are not good thinners, and should not be substituted for turpentine in paints.

Colored pigments should be added to the paste-pigment and oil while the paint is being mixed, rather than to the paint after it has been completely thinned.

Paints are more homogeneous if they are mixed about 24 hours before using. According to some authorities, it is best to mix the drier into paint just before use.

Paints that are not kept in sealed containers become fatty; they will not work smoothly under a brush, and are practically worthless after a short time.

Unless you are an expert paint-manufacturer, you should not use any other drying-oil than linseed-oil in paints.

316. Care of Paint-Brushes.—In order to keep the bristles of a paint-brush straight and in good condition, the brush must receive proper care. Paint-brushes that are not to be used for some time should be cleaned thoroly in kerosene. Benzine, gasoline, and turpentine may be used; but, in general, kerosene is the cheapest and most satisfactory cleaner. A brush which has been cleaned in kerosene should be allowed to dry out, or should be placed in turpentine before being used in paint again. If a brush is to be dried out and put away, it is advisable to wash it with hot water and soap, after it has been cleaned in turpentine or kerosene.

---

[18] See Alvah Horton Sabin, *Technology of Paint and Varnish*, pp. 155-158.

Brushes that are to be used in paint again in a few hours may be kept suspended in linseed-oil in such a position that the bristles will not curl from the weight of the brush.

Paint-and-varnish removers, and sometimes amyl or butyl acetate, are good solvents for cleaning brushes that have become partly hardened with paint. These strong solvents will often save a paint brush that at first sight seems to be about ruined. A final cleaning in turpentine or kerosene will leave a brush in a suitable condition for use at a later time.

317. Care of Painters' Rags. — The most important warning that should be given to a young painter is: *take care of the paint-saturated rags.* Many serious fires have occurred because a thoughtless painter forgot to take rags that were partly wet with paint out of the building or to burn them in a furnace.

Paints contain linseed-oil or some other drying-oil. Heat is generated by all drying-oils during the oxidation process, and oil-soaked cloth will become hot enough to ignite whenever oily rags are thrown into a pile. During the day rags and waste containing even a small amount of linseed-oil should be thrown into a special fire-proof waste-can. Every particle of waste or rags that painters have used in wiping off paint, or any wood-finishing material containing linseed-oil or any other drying-oil, should be burned or taken outdoors. There is little danger from linseed-oil or paint on a piece of cloth or canvas which is stretched so that the air can keep the surface cool. If, however, the same piece of cloth which is full of wet paint be rolled up into a tight wad, there will be slow generation of heat, and fire is apt to appear in time. The careful painter watches for oil-soaked rags, and oil-soaked clothes, and has no trouble from fires caused by spontaneous combustion.

FINISHES FOR TYPICAL WOODS

Kinds of Wood	Planing	Scraping	Sanding	Sponging	Resanding	Water-Staining	Oiling	Oil-Staining	Shellac-Wash	Dusting	Paste Wood-Filler	Sanding	Dusting & Cleaning	Shellacking	Sanding	Reshellacking	Cleaning	Varnishing	Sanding	Revarnishing	Rubbing-Pumice	Polishing	Cleaning	Flat Varnish	Lacquering	Relacquering	Rubbing	Cleaning	Polishing	Waxing
Cedar, Red	X		X										X	X	X	X														
Cypress	X		X					X					X	X	X		X								X	X	X	X		
Pine, Yellow	X		X					X					X	X	X		X	X	X	X	X		X							
Ash	X	X	X	X	X	X			X	X	X	X	X	X	X		X	X	X	X	X		X							
Basswood	X		X					X					X	X	X		X								X	X	X	X		
Birch	X	X	X	X	X	X							X	X	X		X	X	X	X	X	X	X							
Butternut	X	X	X							X	X	X	X	X	X		X	X	X	X	X	X	X							
Cherry	X	X	X											X	X										X	X	X	X	X	
Chestnut	X	X	X					X		X	X	X	X	X	X		X	X	X					X						
Gum, Red	X	X	X	X	X	X							X	X	X		X	X	X	X	X	X	X							
Mahogany	X	X	X	X						X	X	X	X	X	X		X	X	X	X	X	X	X							
Maple	X	X	X										X	X	X		X	X	X	X	X	X	X							
Oak, Natural	X	X	X							X	X	X	X	X	X		X	X	X	X	X	X	X							
Oak, Stained	X	X	X	X	X	X			X	X	X	X	X	X	X		X	X	X	X	X	X								
Oak, Mission	X	X	X	X	X	X							X	X	X										X	X				X
Poplar	X	X	X	X	X	X							X	X	X		X	X	X					X						
Sycamore	X	X	X										X	X	X		X	X	X	X	X	X	X							
Walnut, Black	X	X	X				X		X	X	X	X	X	X	X		X	X	X	X	X	X	X							

TABLE 8—FINISHES FOR TYPICAL WOODS

REFERENCES—CHAPTER XVII

Paints and Painting

J. Gauld Bearn, *The Chemistry of Paints, Pigments, and Varnishes*, "Pigments," pp. 27-151.

Ch. Coffignier, *Colors and Varnishes.*

G. B. Heckel, *A Paint Catechism for Paint Men.*

A. Ashmun Kelly, *The Expert House-Painter.*

A. Ashmun Kelly, *The Expert Paint-Mixer.*

C. A. Kunou, *Manual of Gilding and Compo Work.*

William S. Lowndes, *Painting and Wood-Finishing.*

F. Maire, *Colors—What they are and what to expect of them.*

R. A. McGee and A. G. Brown, *Instruction Units in Wood-Finishing*, pp. 63-73.

R. S. Morrell and A. de Waele, *Rubber, Resins, Paints, and Varnishes*, "Pigments," pp. 108-162.

A. C. Newell, *Wood and Lumber*, "Wood Cells," pp. 28-43; "Rot-Fungi," pp. 154-7; "Creosote-Oil," pp. 161, 2.

A. H. Sabin, *House-Painting.*

A. H. Sabin, *Technology of Paints and Varnish.*

Sherwin-Williams Company, *How Paints and Varnishes are Made.*

Charles Henry Snow, *Wood and Other Organic Structural Materials* Chapter XV.

S. W. Stratton, *Materials for the Household*, Bureau of Standards, United States Department of Commerce, Circular No. 70.

S. W. Stratton, *Paint and Varnish*, Bureau of Standards. United States Department of Commerce, Circular No. 69.

F. N. Vanderwalker, *House-Painting Methods.*

F. N. Vanderwalker, *The Mixing of Colors and Paints.*

INDEX

A

Acetates and alcohol as lacquer solvents, 292
Acetic acid in polishing oils, 280
Acetone in varnish-removers, 282
Acid azo dyes, 112
Acid coal-tar dyes, 117
Acid dyes,
  acetic acid with, 134
  are soluble in water, 118
  cheap and brilliant, 118
  easily soluble, 134
  for use in acid baths, 118
  in wood stains without acid, 118
  not acid in reaction, 131
  on wood, 118
  used as wood-stains, 119
    list of 120-121
  used to dye wool and silk, 124
Acid water-soluble dyes on wood, 130
Acid water-stains under lacquers, 325
Acridine colors, 115
Air-seasoned lumber unsatisfactory, 15
Air-spraying outfits, 331
Air-gun, use of with lacquers, 330
Alcohol,
  absorption of water by, 174
  affinity of for water, 180
  amyl, 311
  butyl, 311
  denatured, high proof, in shellac, 173
  ethyl,
    solvent power of for resins, 292
    as a lacquer-solvent, 297
  in shellac-varnish, 173
  polishing, spiriting-off, 281
Alizarine dyes, 111
  acid, 114
  synthetic madder, 100
Alkalies,
  destroy Prussian blue, 369
  fixed, for fumed-oak color, 69
  used on wood, 67-68
  volatile, and fixed, as stains, 68
Alkaline wood stains, 39
Aloes extract, 99
Aluminum paint, 374
Aluminum stearate,
  dulls lacquers, 336
  in flatting oils, 344
  in mixing varnishes, 255
  in varnishes, 254
Aluminum varnish kettle, 232
Amber,
  in varnish, 212, 214
  not now available, 222
Ammonia,
  fuming of various woods, 70
  process of fuming oak, 70
  strong, effective stain, 68
Amyl acetate,
  as a lacquer-solvent, 301
  brush cleaner, 392
  for brush cleaning, 283
  use in lacquers, 310
Amyl alcohol, use in lacquers, 311
Analogous colors, 85
Aniline, 104
  derivation of, 107
  source of, 111
Aniline dyes,
  are subdivision of coal-tar dyes, 104
Animal dyes, 95
Animi resin not available, 222
Anthracene,
  dyes, 114
  oil, 108
Anthraquinone dyes, 114
Antimony,
  butter of, 280
  oxide, or white antimony, 355
  white, non-poisonous paint pigment, 355
Antwerp blue, 369
Application of paints, 386
Applying stains, 61
Architectural varnish, 251
Asbestine as a paint extender, 357
Ash,
  filler for, 146
  finishing of, 393
Asphaltum black, as an oil-stain, 50
Aurantine dye, 101

Aurora yellow, 368
Automobile,
  lacquers, 313
  varnish, 251
Azo,
  acid dyes, 117-118
  compounds, 112
Azine dyes, basic and acid, 113

B

Baking-enamels, medium-oil varnishes for, 253
Baking-varnish, 251
Barium sulphate,
  inert paint pigment, 255
  in lithophone, 356
Barytes,
  as a paint pigment, 355
  cheap adulterant for paints, 356
Basic dyes,
  azo, 112
  brilliant but fugitive, 119
    for spirit-soluble wood-stains, 125
  from various chemical groups, 119
  more fugitive than acid, 132
  on leather, 125
  on wood, 125
  require mordants on cotton, 124
  soluble in water and alcohol, 131
  use as wood-stains, list of, 122-123
  used on wood without mordants, 133
Basswood, finishing of, 393
Beeswax, in flat varnishes, 255
Benzene,
  a lacquer thinner, 307
  boiling point of, 107
  from light tar-oil, 111
  not the same as benzine, 307
Benzine, 240
  excess of in short-oil varnishes, 266
  functions of in varnishes, 248
  in enamels, 196
  in lacquers, 307
  in paint, 345
  in varnishes, 238
  not good in paints, 391
Benzol,
  in enamels, 196
  in oil-soluble stains, 129
  in paints, 382
Benzol—*Cont.*
  in priming paint on certain woods, 387
  in wood-fillers, 153
  solubility of gums in, 307
Benzyl alcohol, as a lacquer-solvent, 302
Berenice, old name for amber, 212, 213
Berenice's hair, story of, 212
Bichromate of potash with direct dyes, 126
Birch,
  filler for, 146
  finishing of, 393
Bismarck brown in shellac, 187
Black lead, or graphite, 360
Black paint, 382
Black pigments, 359
  list of 343
Blanc fixe,
  base for "lake" colors, 355
  or precipitated barytes, 355
  with titanox, 354
Blending agents in lacquers, 307
Blending colors, 382
Blocks for sandpapering, 30
Blue,
  Antwerp, 369
  Chinese, 369
  cobalt, permanent, expensive, 370
  paint, 383
  pigments, 368
  Prussian, brilliant color, 369
  sky, paint, 383
  ultramarine, complex compound, 368
Blushing,
  and plasticizers, 303
  in lacquer films, 298
  of shellac-varnish, 180
  or cloudy effects in lacquer films, 299
Bone black, 359
Brass paint (yellowish), 383
Brazil-wood dye, 101
Bronze,
  green, paint, 383
  paints, 374
Bronzing liquids, 374
Brown,
  paint, various mixtures, 383

Brown—*Cont.*
  pigments,
    list of, 371-372
    sepia, 372
    Vandyke brown, 373
Brunswick green, 370
Brush,
  cleaners for paint, 392
  cleaning liquids, 283
Brushes,
  care of with water-stains, 47
  for chemical staining, 68
  for lacquering, 327
  for varnishing, 268
  kinds of used with water-stains, 47
  use of in staining, 61
Brushing,
  paint into wood cells, 388
  wood before filling, need of, 151
Brushing-lacquer,
  brushes for, 327
  clear, for wood, 312
  thickness or "body" of, 329
Buckles for white lead corroding, 347
Buff, 81
  paint, 383
Burmese lacquers, 286
Burnt,
  sienna, 364
  umber, 372-373
    good oil-stain color, 373
    is a strong drier, 373
Butternut, finishing of, 393
Button-lac, 172
Butyl acetate,
  as a brush cleaner, 283, 392
  as a lacquer-solvent, 300
  used in lacquers, 310
Butyl alcohol,
  as a lacquer-solvent, 300
  or butanol, used in lacquers, 311
Butyl propionate,
  use in lacquers, 310

C

Cabinet-maker's cement for holes, 24
Cadmium yellow, 367
Calcimines, 345
Calcium carbonate or whiting, 356
Camphor in shellac, 179
Camwood bark, 102
Carbolic oils, 107
Carbon black, intense black, 359
Carmine, from cochineal, 364
Castor-oil,
  as a softener, 304
  with colors in lacquers, 316
Catalysers, 241
Catechu, 100
Cedar,
  oil, in polishing oils, 280
  oil of, ancient use of, 213
  red, finishing of, 393
Cello Solve, as a lacquer-solvent, 298
Charcoal black, artists' color, 360
Chemical staining,
  brushes for, 68
  fumed-oak color, 69
  precautions with, 68
  preparation of a wood surface for, 68
Chemical Stains, 64
  chemicals used in, 66
  definition of, 64
  good on few woods, 65
  protection of hands with, 68
  reaction of woods to, 64
  tannic acid reacts with iron parts of brushes, 66
  waning popularity of, 65
Chemical theory of dyeing, 93
Cherry,
  color for paints, 364
  filler for, 146
  finishing of, 393
Chestnut,
  filler for, 146
  finishing of, 393
China clay, 358
  or kaolin, in fillers, 142
China wood-oil, 234
  in enamels, 199
  in flatting oils, 344
  in varnishes, 222
  see tung-oil also, 234
  special functions of in varnishes, 248
Chinese blue, 369
Chinese lacquers, 285, 286
Chroma, 78
Chrome,
  green, a mixed color, 370
  orange, 366
  or Brunswick green, 370

Chrome—*Cont.*
  oxide green, 371
  yellows, 366
    brilliancy of, 367
    unsatisfactory with Ultramarine blue and sulphur colors, and alkalies, 366
Chromic acid,
  in wood-stains, 39
  used in chemical stains, 66
Citrine, mixing the color, 81
Citronella, oil of, used in polishing-oils, 280
Cleaning liquids for paint brushes, 392
Cleanliness improved by paints, 341
Close-grained woods, stain for, 53
Coach black, 360
Coach-varnish, 252
Coal-tar, 104
  blacks, 98
  distillation, products of, 107
Coal-tar dyes,
  acid, 117
    colors for wood, list of, 120-121
  American now permanent, 106
  American production of, 106-107
  and their use as wood-stains, 104
  azo compounds, 112
  basic, colors for wood, list of, 122-123
  characteristics and origin, 104
  chemists' classification of, 112
  classified by application, 116
  crudes and intermediates for, 111
  history of, 105
  include aniline and others, 104-105
  list of application groups, 117
  list of first colors, 105
  number of, 104
  shortage of during war, 105-106
Coats of paint, number of, 386
Cobalt,
  blue, artists' color, 370
  driers, 241-242
  green, 371
Cochineal, 95
Colophony, see rosin, 246
Colored pigment mixing, 382
Coloring-matter in fillers, 144
Color circle,
  modern 10-point, 87
  12-step, 82
Color combinations, acceptable, list of, 88
Color,
  harmony in, 85
  Index, 104
  modern theory of, 86
  triads, and near complements, 84
  triads of, 83
Colored lacquers, 317
Colors,
  analogous and contrasting, 85
  and wood-stains, 78
  chroma, and tints and shades of, 78
  coal-tar, 93
  complementary, 82
  complex mixed, 81
  contrasting, 83
  dry, difficult to mix with oil, 376
  in lacquer-enamels, 313
  in varnishes, 266, 267
  mixed in putty, 389
  most used in stains, 90
  neutral, 81
  olive, citrine, and russet, 81
  palette of for staining, 89
  pigment-complements of, 83
  prismatic of the solar spectrum, 79
  quaternary, 81
  secondary, 80
  tertiary, 81
  three primary, 79
  used as trimmings, 89
  used in shellac, 187
  used in wood-stains, 78
  value, tone, saturation of, 79
  variety of in ancient times, 339
  warm and cold, 79
  water-soluble, solubility of, 133
Complementary colors, 82
  near, 84
Congo
  copal, function of in varnishes, 246
  gum, 222
Contrasting colors, 86
Cooking of varnishes, 220
  effects of, 226
Copal, meaning of, 222
Corroding lead, 348
Cotton,
  nitrating of, 290
  soluble, 290
Cotton linters, for nitrocotton, 290

Crudes, for dyes, 111
Crusher's drier, 346
Cracking of rosin varnishes, 229
Cracks, filling of, 24
Cream paint, 384
Creosote oil, 108
  used as wood stain, 37
Creosote oil-stains, 54
  as a wood-preservative, 54
  formula for shingles, 55
Cutch or catechu, 100
Cypress, finishing of, 393

D

Dakalite wood-stains, 40
Dammar, 164
  gum, solubility of, 165
Dammar-resin,
  in lacquers, 293
  origin of, 166
Dammar-varnish, 165
  application of, 166
  brilliance and durability of, 165
  composition of, 166-167
  drying of, 165
  in baking varnish, 252
  in gloss enamels, 197-198
  in paints and enamels, 166
  in white enamels, 194
  not durable, 252
  paleness of, 166
  transparency of, 166
Danger from lacquering, 333
Decoration by paints, 340
Defects on surfaces, 20
  removal of before sandpapering, 26
  repair of with sawdust and glue, 24
Dents, removal of by heat and water, 25
  repair of, 25
Developing dyes, 128
Diethyl carbonate,
  as a lacquer-solvent, 299
  use in lacquers, 310
Diluents,
  evaporate from lacquer films, 308
  for lacquers, 294
  in lacquer formula, 311
  in lacquers, 306
  in lacquers are cheap, 308
Direct dyes, 125
  solubility and use of, 126
Drab paint, 384
Driers,
  amount absorbed by rosin and linseed-oil, 242
  and their functions in oils, varnishes, and japans, 240
  are salts which change oxygen content, 241
  chemical action of, 241
  cobalt, 242
  concentrated, 243
  contain oils and drying salts, 217
  crusher's drier, 346
  function and use of in varnishes, 249
  in paints, 346
  in water-proof varnishes, 243
  lead, list of, 242
  manganese, list of, 242
  metallic, in paints and varnishes, 240
  metallic in varnishes, 218
  mixtures of preferred, 243
  oleate of lead, 243
  theory of chemical reactions of, 242
  used in excess, 346
  used in pale varnishes, 243
Drop black, 360
Drying,
  of drying-oils by oxidation, 240
  of lacquer films, 329-330
Drying-oils,
  fire danger from, 280
  functions of in varnishes, 247
  in varnishes, 231
  list of, 230
  oxidation of, 231
  oxidation of in drying, 240
  used in paints, 344
Drying salts, origin of, 240
Drying speed of lacquer films, 334
Dull finish rubbing, 274
Dust,
  from lacquering with air-gun, 333
  in finishing-room and clothes, 269
Duster-brushes, 149
Dusting,
  before filling, 150-151
  before varnishing, 268
  sandpapered surfaces, 35

Dusting—*Cont.*
  wood before finishing, 36
Dutch Process white lead making, 347
Dyeing,
  chemical theory of, 93
  mordants for, 94-95
  or coloring wood, 132
  theories of, 93
Dyes,
  acid,
    acetic acid with, 134
    and basic do not mix, 131
    are alkaline salts, 131
    easily soluble, 134
  American coal-tar, permanent, 106
  animal, 95
    cochineal, 95
    kermes, 96
    sepia, 96
    Tyrian purple, 96
  chemical, composition of, 93
  classes,
    not used on wood, 132
    used in staining, 132
  classification of, 109
  coal-tar, 92
    chemist's classification of, 112
  color numbers of, Shultz and Color-Index, 109
  concentration of, 110
  crudes and intermediates for, 111
  developing, 128
  direct, on wood, 131
  fastness of, 110
  for wood-finishing, classes of, 130
  for wool, wood, and silk, 131
  heat may decompose, 135
  identification of, 109-110
  mordant, 127
  more soluble in hot water, 134
  naming of, 109
  oil-soluble,
    for wood-stains, table of, 129
    hard to dissolve, 134
    solubility of, 135
    solvents for, 129
  pigment, 127
  salt, direct, or substantive, 125
  solubility of, 111
  sources of, 92
  straining a mixture of, 134
  sulphur, 128
Dyes—*Cont.*
  useful as stains, 92
  vat, 128
  vegetable, 96
    Brazil-wood, 101
    indigo, 98
    logwood, 97
    osage orange, 101
    red sanders or red sandalwood, 102
    textile, ancient, 97
    tumeric, 101
  water, kind of, used in, 134
  water-soluble, solubility of, 133
Dyestuff, definition of, 92

E

Earth greens, 370
East India soft gum, in varnishes, 254
Ebony, filler for, 146
Egyptian pigments, 339
Elastic varnishes,
  containing ester-gum, 267
  containing linseed-oil, 267
  long-oil type, 267
Elasticity
  of lacquer films, 305
  of varnishes, 266
Emeraude green, 371
Enamel finish,
  cheap, 207
  preparation for, 201
Enamel grinding mills, photograph of, 193
Enameling,
  covering-capacity of undercoats of paint for, 210
  drying of priming coat for, 203
  finishing coats, 206
  flat-paint undercoats for, 204
  lithophone undercoats for, 205
  of old furniture, 208
  over old finishes, 208
  priming-coat, 203
  sandpapering the priming coat, 203
  shellac over a priming coat, 203
  specifications and procedure, 202
  success in, 209
  temperature for, 207, 209
  time for puttying, 203

Enameling—*Cont.*
  undercoats,
    preparation for, 210
    sandpapered for, 205
  use of warm enamel, 209
Enamels,
  adherence of, 210
  and enameling, 192
  application of, 206, 208
  are varnish-paints, 218
  baking, 198
  characteristics of, 192
  cheap, 201
  chief function of, 192
  coloring of, 197
  composition of, 193
  containing long-oil varnishes, 194
  dammar-varnish in, 194
  drying of, 209
    time of, 192
  drying-oils in, 201
  durability of, 201
  exterior, 199
  finished with varnish, 207
  flat, 200
  flatted with flat mixing-varnish, 255
  flat varnishes in, 200
  flat with little varnish, 200
  for outside use, 198
  gloss, 197
    oil varnish in, 198
  in gloss paints, 198
  knots shellacked under, 202
  lithophone dulls luster of, 200
  lithophone in, 194
  marine, 199
  over flat paints, 202
  over gloss paints, 202
  pale oil-varnishes in, 198
  polishing or rubbing, 198
  puttying under, 202
  reducers or thinners for, 206
  rosin in, 196
  rubbing of, 207
  rubbing with pumice-stone, 199
  satin-finish, 200
  shellac as an undercoat for, 203
  short-oil varnish in, 200
  stirring and straining of, 210
  thinner for, 196
  treated for easy spreading, 209
  turpentine in, 196
Enamels—*Cont.*
  turpentine in flat paints under, 204
  types of, 197
  undercoats for, 201
  used in water, 199
  varnish as a binder, 195
  varnish-gums in, increase adhesion of, 196
  vehicles for, 194
  water-proof, 199
    baking on, 199
  without gloss, 200
  zinc white, body pigment for, 194
Enamel undercoat paints, 381
Enamel undercoats, composition of, 204
Enamel-varnishes, 252
  in last undercoat for enamels, 204
  long-oil, 253
  pale, 253
End-grain of wood,
  porosity of, 28
  staining, 46
Ester-gum, 229
  in elastic varnishes, 267
  in lacquers, 293
  in mixing varnishes, 230
  in water-proof varnishes, 230, 265
  its use in varnishes, 246
  manufacture of, 230
  melting point of, 230
  nearly neutral in reaction, 230
  varnishes, in enamels, 253
Esters as plasticizers and softeners, 304
Ethyl acetate,
  as a lacquer-solvent, 298
  use in lacquers, 310
Ethyl alcohol,
  anhydrous,
    as a gum solvent, 292
    use in lacquers as a lacquer-solvent, 297
  denatured, in shellac, 173
Ethyl lactate,
  as a lacquer-solvent, 301
  use in lacquers, 310
Extenders,
  for paints, 342
  functions of, 343
Exterior enamels, 199
Exterior varnish, 252

F

Felts for rubbing, 276
Ferric oxide, in Venetian red, 362
Filled pores of wood, Fig. 4, 29
Filled surface,
  final cleaning of, 160
  highly magnified, 159
  sandpapering of, 159
Filler,
  brushes and picking-sticks for, 149
  containing benzol, 153
  liquid, ready-mixed, 141
  removal of when too hard to rub, 149
  thinning of, 153
  type required depends on porosity of wood, 162
  types of, used on common woods, 160
  wood, in tracheal vessels, 137
Filling,
  and staining in one operation, 152
  process of, 152
  without lifting stain, 152
Finishing-varnishes, 253
Fire danger from drying oils, 280
Fitch-brushes, 327
Flatting effects of turpentine, 375
Flatting-oils, in paints, 344
Flavin, 103
Floor-paints contain varnish, 344
Floor-varnishes, 255
Flowing varnish, 256
Formulas for paint and varnish removers, 283
Forest green, filler for, 146
Fossil varnish-gums, 221
French ochers are superior, 365
French polishing, 185
  application of, 188
  colors sometimes used with, 187
  drying of coats of, 188
  formulae for, 187
  number of coats used in, 188
  on a lathe, 189
  pad for, 188
  pumice-stone as a filler for, 188
  shellac mixtures for, 186
  spiriting off in, 188
  spiriting off on lathe finishes, 190
  used on close-grained woods, 186
  various procedures for, 186
French Polishing—*Cont.*
  with varnish, 281
Fumed-oak,
  ammonia-process, 70
  chronological steps in finish, 76
  with fixed alkalies, 69
Fuming-box, 72
Fuming process,
  articles separated in, 72
  oiling after fuming, 75
  tests for color in, 73
  time required for, 73
  on white oak, 71
  refuming light streaks, 74
  sap-streak doctoring, 74
  strength of ammonia required, 72
  uniform results in, 74
Furniture polishes, 280
Furniture varnishes, 256, 268
Fustic, 101
Fuzz,
  on surface of cypress board, photomicrograph, 43
  on surface of oak wood, 151
  on wood, removal of, 33
  removal of,
    before filling, 152
    before or after water-staining, 43

G

Gallnuts, 100
Garnet-lac, 172
Gear and Chassis varnish, 256
Gilder's white, 357
Gilsonite, 217, 253
Gloss enamels, 197
Gloss-oil varnishes, 257
Gloss paint for finishing coat, 390
Gloss-varnishes in paints, 344
Glycol ethers, use of in lacquers, 299
Gold paint, 384
Graphite or black lead, 360
Graphite paints, 361
Gray, filler for, 146
Gray paint, 384
Green paints, 384
Green pigments,
  chrome oxide green, 371
  classes of, 370
  cobalt green, 371
  emeraude green, 371
  permanent green, 371
  viridian, 371

Greens,
  Brunswick, 370
  earth, 370
Grinding colors in oil, 376
Grinding-japan colors, 315
Grinding-japans, 244, 258
Grinding-varnishes, 257
Grinding white lead, 350
Gum turpentine, 237
Gums, varnish, soluble in drying oils, 216
Gumwood, red, finishing of, 393
Gun-cotton explosive, 291
Gun metal black, filler for, 146
Gypsum, burnt, extender for Venetian red, 362

H

Hard-oil varnish, 258
Harmony in colors, 85
Heat-proof varnish, 258
Holes in wood, filling of, 24
Hue, 78
Hydrocarbon solvents, 307

I

Indian red, 362
  in ferric oxide, 362
Indigo, 97, 98
  synthetic, 98
  vat dye, 130
Indigoid colors, 116
Inert paint pigments, 342
Inside wall paints, flat, 380
Inspection before sandpapering, 26
Insulating varnish, 259
Interior varnish, 258
Iron pigments, list of, 343
Ivory black, 359
  ground in japan, 360
  very dense and opaque, 360
Ivory paint, 384

J

Japanese lacquers, 285, 286
  japan, 286
  baking, 217
  colors in lacquer-enamels, 315
  composition of, 217
  contains gums, 218
  driers,
    composition of, 243, 346
    purpose of, 217
Japanese lacquers—*Cont.*
  grinding, 244, 258
  gums used in, 243
  painters', 243
  thinners in baking, 217
  varnishes, and driers, 216, 217
Jet black, 360

K

Kauri,
  fossil resin, 223
  gum, function in varnish, 246
  pine trees, 223
  resin, 223
    cost of, 224
    digging of, 223
    grades of, 223
    in high-grade varnishes, 224
    melting temperature of, 224
Keg-lead, 375
Kermes, 96
Kerosene, 240
  as a paint brush cleaner, 392
  in paints, 345
  not good paint thinner, 391
  use in varnishes, 249
Kiln-dried lumber reabsorbs moisture, 15-16
Knots,
  prevention of exudation from, 177
  shellacking of, before painting, 386

L

Lac,
  dye, 171, 172
  insects, infest new trees, 171
Lacquer
  and shellac mixtures, 337
  application of, 325-326
    is difficult, 289
  brief history of, 285
  brush-cleaner, 329
  brushing, formula for wood, 312
  Burmese, 286
  characteristics of varnish-resins in, 292
  Chinese, 285
  colored, 317
    with coal-tar dyes, 315
  cost of reduced by use of varnish-resins, 292
  diluents, 294
    characteristics of, 308

Lacquer—*Cont.*
  drying time of, 333-334
  enamels, 289
    black, 313
    durability of, 317
    durable on automobiles, 317
    holds color while drying, 319
    japan colors in, 315
    mixing colors in, 315
    or, colored lacquers, 314
    pigment oil colors in, 315
  expensive, 308
  films,
    are heat resisting, 337
    are thin, 323
    defects of, 321
    density and strength of, 293
    hardening speed of, 335
    not easily damaged, 335
    polishing of, 336
    rubbing of with pumice-stone, 336
    sanding, rubbing, and polishing of, 334
    sandpapering, 329
    waxing over, 336
  finishes,
    advantages of, 319
    and lacquering technic, 319
    disadvantages of, 320
    drying time for, 330
    have low gloss, 321
    over drying oils, 324
    popularity of, 289
    undercoats for, 321
  flat, 336
  for automobiles, 293, 313
  formerly contained sandarac gum, 169
  formula, general, 309
    amount of ingredients used, 309-311
    chemical and general information, 309-311
    diluents, functions of, 311
    functions of ingredients, 309-311
    gum or resin solvents, 310
    ingredients in lacquer, 309-311
    plasticizers, 309
    solvents for nitrocellulose, 310
    varnish-resins, 309
  for wood, 291

Lacquer—*Cont.*
  from spirit-varnishes, 287
  history, use, composition, 286
  Japanese, 285
    hardened by darkness and moisture, 285
  list of resins used in, 292
  meaning of term, 289
  nitrocellulose,
    composition of, 290
    with gums, 288
    without gums, 288
  nonsolvents,
    list of, 295
    meaning of term, 295
  now contain varnish-resins and nitrocellulose, 288
  oriental, 285
    are varnishes, 287
  over spirit soluble stains, 321
  pigmenting of, 316
  plasticizers and oil-colors, 315-316
  quantity of resins in, 293
  reaction to linseed oil, 316
  resins,
    characteristics of, 292
    combination of in lacquers, 293
  rubbing, sandpapers for, 335
  solvents,
    acetates and alcohol, 292
    active and nonsolvents, 295
    active, list of, 295
    characteristics of, 294
    classification of is difficult, 295
    classified by boiling-points, 296
    mixtures, 294
  solvents in, 292
  spirit-varnish gums in, 287
  spirit-varnish type thin, 287
  spraying,
    formula for, 312
    pressure for, 333
  transparent or clear, 313
  undercoats, 336
    special, 323
  undercoat stains, 325
  unpigmented, decompose in sunlight, 313
  uses of, 289
Lacquering,
  brushes for, 327
  danger of in schools, 333
  drying time of coats, 334

Lacquering—*Cont.*
  dust from spraying, 333
  hints for inexperienced, 327
  impossible over certain undercoats, 322
  over old finishes, 325
  over old varnish finishes, 326
  over porous woods, 328
  over shellac, 324
  over shellac undercoats, 320
  preparation of surfaces for, 326
  speed required usually, 328
  spraying-outfits for, 330
  unsatisfactory over linseed-oil compounds, 322
  use of spray-gun for, 331
  with a brush, 327
  with an air-gun, 330
Lake colors, 364
Lake greens, 370
Lakes,
  coal-tar colors on blanc fixe, 370
  dyes on blanc fixe, 364
Lampblack, 359
  used by ancient Egyptians, 339
Lavender paint, 384
Lead,
  acetate, function in varnishes, 249
  black, 360
  carbonate,
    and hydrate with drying-oils, 349-350
    or white lead, 342
  corroding, photograph of stack, 348
  driers, 241
    in varnishes, 239
    list of, 242
  hydrate, 349-350
  keg, 375
  pigments, in colors, 343
  poisoning, 391
  red, 363
  sulphate,
    basic, 351
    with sulphur gasses, 351
  white,
    composition of, 346
    manufacture of, 347-348
Leveling properties of varnishes, 266
Lifting,
  of stain by filler, 152
Lifting—*Cont.*
  of volatile oil-stains, 57
Lighting effects of paints, 341
Linseed-oil, 232
  amount used in varnishes, 247
  and tacky lacquers, 307
  bleached, 232
  function of in varnishes, 247
  heat treated with driers, 232
  in ancient varnishes, 214
  in elastic varnishes, 267
  information about, 247
  only good paint oil, 391
  on rags, and spontaneous combustion, 392
  pale, 232
  under paste filler, 153
  viscosity of, 236
  weight of, 234
Liquid filler, covering power of, 140
Litharge,
  combined with red lead, 362
  in tung-oil, 234
  used in varnishes, 249
Lithopone,
  characteristics of, 205
  formation of, 356
  for undercoat paints, 353
  in enamels, 194
  obscuration of, 353
  paint, tests for, 205
Logwood,
  chips, 98
  extract, 97
Long-oil ester-gum varnishes, 265
Long-oil varnish, dries slowly, 259
Luster of varnishes, 266

M

Madder,
  colors for stains, 100
  extract, 99
  plant, 99
Magenta, a basic dye, 105
Magnesium silicate or asbestine, 357
Manganese dioxide, 218
  function in varnishes, 249
Manganese driers, 242
  in varnishes resist moisture, 243
Mahogany,
  color, for paints, 364
  finishing of, 393

Mahogany—*Cont.*
  paint, 385
  stains, not used under lacquers, 325
  various fillers for, 146
Manila gum,
  for pale inside varnishes, 226
  hard or fossil, functions in varnishes, 245
  soft and hard, 225
Manjak, 253
Maple, finishing of, 393
Marble-dust in putty, 389
Marine enamels, 199
Marine varnish,
  composition of, 259
  is water-proof, 259
Mastic,
  and dammar varnish, 168
  gum,
    solubility of in turpentine and alcohol, 165
    solvents for, 168
  varnish,
    characteristics of the gum, 167, 168
    origin of, 167
    used by artists, 168
Mauve, an aniline color, 105
Mechanical theory of dyeing, 93
Meglip, for artists, 168
Menhaden oil, in varnish, 258
Metal paints of red-lead, 381
Metal surface cleaning, 202
Metallic pigments, 373
Methylene blue and green, 116
Mineral oil thinners, 239-240
Minium, 363
Mission-oak oil-stain, 50
Mixing,
  dyes, 134-135
  paint by hand, rules for, 377
  varnishes, amount of oil in, 255
  varnish, resins in, 260
Monoethyl ether of ethylene glycol, as a lacquer-solvent, 298
Mordant dyes, 127
  vegetable, going out of use, 127
Mordants, 94

N

Naphtha,
  functions and use in varnishes, 248
Naphtha—*Cont.*
  in lacquers, 307
Naphthalene, 98
Naphthol yellow, 115
Negative varnishes, contain sandarac, 169
Neutral colors, 81
Nigrosine,
  acid water-soluble, 113
  spirit-soluble, 113
Nitroso and nitro dyes, 114
Nitrating cotton, 290
Nitrobenzene, 104
Nitrocellulose,
  amount used in lacquers, 309
  kept wet in alcohol, 291
  lacquers,
    composition of, 290
    high viscosity of early types of, 291
  low viscosity type of, 291
  nonsolvents for, 310-311
  or pyroxylin, 290
  pigmented, 316
  solvents, 310

O

Oak,
  antique, filler for, 146
  Antwerp, filler for, 146
  bog, stain and filler for, 146
  Baronial, stain and filler for, 146
  dark, filler for, 146
  Dutch brown, 147
  early English, 147
  Flemish or Flanders, 147
  fumed, filler for when used, 147
  golden, stain and filler for, 147
  Jacobean, no filler, 147
  Malachite, stain and filler for, 147
  mission,
    filler for when used, 147
    finishing of, 393
  natural finishing of, 393
  olive, stain and filler for, 147
  silver or Kaiser, filler and stain for, 148
  stained, finishing of, 393
  stains and various fillers for, 146
  weathered, fillers when used for, 148
Obscuration by paints, 340
Ochers,
  golden, fade, 366

Ochers—*Cont.*
  in priming paints, 387
  yellow and golden, 365
Oil,
  colors,
    grinding of, 376
    not equal in brilliancy, 51
  driers, 346
  drying, 218
    used in varnishes, 216
      during the middle ages, 215
  formulas for use in polishing, 280
  for rubbing, 277
  of cedar,
    in polishing oils, 280
    use of in ancient times, 213
  or oleoresinous varnishes, 212
  oxidizing, 218
  polishing with rottenstone, 279
  rubbing,
    not used between coats, 277
    to satin-finish, 276
  soaked rags and clothes, danger of, 392
  solvents, 236
  tung- or China wood-oil, 234
  used in polishing, 279
Oil-soluble dyes,
  hard to dissolve, 134
  list of, 130
  not distinct class, 130
  solubility of, 135
  solvents for, 130
Oil-soluble stains,
  strength of color of, 135
  table of, 139
Oil-stains,
  application of with a brush, 54
  colored pigments in, 50
  creosote, 54
  dry colors in, 51
  drying of, 53
  lifting of color, 53
  on close-grained woods, 53
    cypress wood, 50
    porous woods like cypress, 53
  opaque effects of, 51
  pigment,
    advantages of, 52
    for architectural finishing, 53
    formulas for, 52
    use of, 53
  preparation of pigments for, 51
Oil-stains—*Cont.*
  rubbing of, 53, 54
  three kinds of, 50
  volatile, 55
    shellac-wash over, 56
  with wood filler, 52
Oil-varnishes (see also varnish, varnishes, and varnishing),
  application of, 267
  composition of, 218
  in gloss enamels, 198
  resins in, 218
Oil-varnish gums, soluble in drying oils, 216
Oleate of lead, 243
Olive,
  mixing the color, 81
  paint, 385
Orange,
  chrome, 366
  paint, 385
  red pigments, 364
  shellac, use of, 178
  shellac-varnish, keeping of, 176
Oriental lacquers, 285
  are varnishes, 287
Osage orange dye, 101
Outside paint formulas, 378-379
Oxalic acid, bleaching shellac-varnish with, 175
Oxazine colors, 115

P

Paint,
  aluminum, 374
  antiseptic qualities of, 341
  application of, 386
  black, 382
  blue, 383
    sky, 383
  brass (yellowish), 383
  bronze, 374
    green, 383
  brown, 383
  brushing, 388
  buff, 383
  citron or citrine, 383
  composition of, 342
  containing,
    benzine, 345
    kerosene, 345
    turpentine, 345
      inflammable, 391

Paint—*Cont.*
  covering-capacity of, 379
  cream, 384
  drab, 384
  driers, classes of, 346
  flatting-oils, 344
  formula for a second coat, 378
  for,
    floors, with varnish, 390
    porous woods, 382
    undercoats, with lithophone, 353
  from water-colors, 345
  functions of, 340
  gold, 384
  gray, 384
  green, 384
    permanent, 371
  hints and precautions, 390
  improves lighting effects, 341
  ingredients, characteristics of, 375
  ivory, 384
  lavender, 384
  list of drying-oils for, 344
  mahogany, 385
  making,
    progress slow in, 340
    recent development thru chemistry, 340
  mechanical not chemical mixtures, 342
  mixing,
    by a painter, 377
    formula for, 378
  oil, linseed only good, 391
  olive, 385
  orange, 385
  penetration increased by benzol, 382
  pigments, 342
    opaque, list of, 342
    powdered, 375
  white, classes of, 342
  pink, 385
  preserves wood and iron, 341
  priming, mixing 8% oil white lead paste, 378
  purple, 385
  removal from hands with linseed-oil, 391
  rose, 385
  russet, 385

Paint—*Cont.*
  sanitation and cleanliness improved by, 341
  slate, 385
  stone, 385
  straining, 377
  tan, 385
  thinners, 345
    functions of, 345
  unsealed, becomes worthless soon, 391
  vehicles, functions of, 343
  violet, 385
  walnut, 386
Paint and varnish removers,
  as paint brush cleaners, 392
  used on old finishes, 208
Paint and painting, brief history of, 339
Paint-brush cleaners, 392
Painters' japans, 243
Painters' rags, care of, 392
Painting,
  body coat or second coat, 389
  body coat same color as finishing coat, 390
  cypress and yellow pine
  early Egyptian, 339
  first coat, 378
  knots and resinous woods, 386
  not advisable during wet weather, 386
  number of coats used, 386
  old surfaces, 386
  preparation for, 386
  priming coat, 387
  procedure for, 388
  second coat, with 8% white lead oil paste, 379
  third coat mixture of 8% white lead oil-paste, 379
  third or finishing coat, 390
  trimming coat, 390
Paintings,
  at Pompeii, 340
  early Egyptian, varnished, 339
  prehistoric, 339
Paint's peeling on plastered walls, 388-389
Paraffin, in varnish-removers, 282
Paraffin oil, in polishing oils, 280
Paris white, 357
Parolite, 217, 253

Paste filler, 138
  application of, 153-154
  body material in, 141
  brushes and picking-sticks for, 149
  colors used to mix for various woods, table of, 146
  crosswise rubbing of, 156
  drying of, 158
  forced into pores, 154
  homemade, keeping qualities of, 145
  improper application of, 155
  ingredients in, 143
  in pores of walnut, magnified, 157
  lens examination of in pores, 158
  materials for rubbing of, 156
  names of colors of, 145
  not used over full strength shellac, 152
  oxidation of oil in, 158
  poor application of, 155
  process of filling with, 152
  pulling out of, 154
  required on certain woods, 161
  required on floors, 162
  rubbing off of, 155
  rubbing time for, 156
  rules for application of, 155
  second application of, 156, 158
  setting of, 154
  stirring of, 154
  thinning of, 145, 153
Paste pigments, white lead and zinc-white, 376
Patent bark, 103
Perilla oil, 231
Permanent green, 371
Permanent pigment oil-colors, 51
Petroleum distillates, solvent power of, 240
Phthalates as plasticizers in lacquers, 305
Phthalic acid, 111
Piano varnish, 260
Picking-sticks, 149
Picric acid, 115
  in chemical stains, 66
  in wood-stains, 39
Pigment colors,
  oil-soluble, in lacquer-enamels, 315
  permanent, 51
  required for various woods, Table of, 146
Pigment dyes, 127
Pigmented nitrocellulose, 316
Pigment mixing, colored, 382
Pigment oil-stains, 50
  advantages of, 52
  formulas for, 52
  on house trimming, 54
  use of, 53
Pigment pastes,
  for paints, 375
  of white lead and zinc-white, 376
Pigments,
  black, 343, 359
  blue, 368
  brown, 372
  classes of, 342
  colored, 342
    addition of to paints, 391
    classes of, 343
  extenders, 342
  green, classes of, 370
  inert, 342
    or, extenders, 343
  in lacquers, 312
    absorb ultra-violet rays, 316
  iron, list of, 343
  lead, iron, and black, 343
  metallic, 373
  opaque, list of, 342
  orange red, 364
  red, 361
    natural and artificial, 361
  used by ancient Egyptians, 339
  used in paints, 342
  Vandyke brown, 373
  white,
    classes of, 342
    inert, list of, 342
    or body, 342
  yellow, list of, 365
Pink paint, 385
Pine, yellow, finishing of, 393
Pitch, 108
Plane,
  adjustment of, 19
  bits should be sharp, 18
  proper use of, 19
Plane bits,
  sharpening of, 18
  sharpening straps, 18
Plane-cutter, adjustment of, 19
Planer marks, removal of, 16

Planer used for smoothing, 18
Planing,
  against grain, 22
  with a smooth-plane, 20
  wood by hand, 18
Plastered wall, new, destroys Prussian blue, 369
  painting, 388
  preparation for painting, 388
  white lead paints, 380
Plaster of Paris, 357
Plasticizer and color mixing for lacquers, 313
Plasticizers,
  and blushing, 303
  and softeners add elasticity to lacquer films, 305
  and softeners for lacquers, 302
  in lacquers, 309
Plugs for holes, 24
Plum, 81
Plumbago, or black lead, 360
Polishing,
  enamels, 198
  formula for spiriting-off, 281
  lacquer-finishes, 336
  oil formulas, 280
  oils, 230, 279
    for old furniture, 280, 281
  processes on varnish, 277
    three methods named for, 278
    use of rottenstone for, 278
  varnishes, 260
Pompeian paintings, 340
Pontianak gum,
  functions of in varnishes, 245
  in spar-varnishes, 263
  in waterproof varnishes, 265
Pontianak resin, 224
  in coach varnish, 225
Poplar wood, finishing of, 393
  radial section of, 34
Pores,
  of oak unfilled, illustration of, 151
  of wood, properly filled, 29
Porosity of end-grain of wood, 28
Potassium bichromate, as a stain, 67
Potassium-permanganate, as a stain, 67
Pots for lead, corroding, 347-348
Preservation by paints, 340
Preservative oil-stains, 50
Priming coat,
  of paint, 378, 387
  omitted in repainting, 386
  paints for wood, 382
  paint with benzol, 387
  sandpapering of, 203
Primary colors, 79
  should be brilliant, 80
Prismatic colors, 79
Prussian blue,
  affected by alkalies, 369
  strong, useful color, 369
  unsatisfactory over new plaster, 369
Pumice-stone,
  as a filler for French polishing, 188
  grades of for rubbing, 276
  lump rubbing, 274
  powder and water rubbing, 274
  removal of after rubbing, 277
  rubbing, of lacquer-films, 336
  scratches, 275
Putty,
  coloring of, 389
  drying of, 204
  from oil, whiting, and white lead, 356
  the making of, 203
Puttying,
  after priming coat, 389
  time for in enameling, 203
Purple paint, 385
Pyroxylin or soluble cotton, 290

Q

Quaternary colors, 81
Quercitron, 102
Quinoline colors, 116

R

Rags, painters', danger of, 392
Raw sienna, 364
  permanent ferric oxide color, 367
Raw umber, 372
  as a drier, 372
Red,
  Indian, 362
  pigments, 361
  sandalwood, 102
  sanders dye, 102
  Tuscan, 363
  Venetian, 362

Red lead,
  a drier called minium, 363
  function of in varnishes, 247
  not used with white lead, 363
  paints for metal, 381
Redwood, filler for, 148
Reenameling, 208
Refinishing,
  old painted and enameled surfaces, 208
  with lacquers, 326
Resins,
  combination of in lacquers, 293
  heat treatment of, 221
  in lacquers reduce cost, 292
  in polishing varnishes, 260
  in oil-varnishes, 218
  in rubbing varnishes, 262
  quantity of in lacquers, 293
  solubility of in benzol, 307
  soluble in benzol or turpentine, 165
  synthetic, in lacquers, 293
  used in lacquers, list of, 292
    solubility of, 292
  used in spirit-varnishes, 164
  used in various varnishes, 245-246
  varnish, characteristics of in lacquers, 291
Repolishing oil for old furniture, 280, 281
Resinates,
  formation of, 227
  less acid than rosin, 227
  melting point of, 228
  treatment of, 227
Rose paint, 385
Rosewood, filler for, 148
Rosin,
  absorptive power of for driers, 242
  acidity of, 229
  and resinates, 226
    neutralized, 262
  composition of, 226, 227
  C.P. or treated, 229
  fluidity of, 229
  in enamels, 196, 201
  in high-grade varnishes, 228
  in water-proof varnishes, 264
  its use in varnishes, 264
Rosin—*Cont.*
  luster of in varnishes, 267
  origin of, 226
  solubility of in turpentine and alcohol, 165
  treated with heat and lime, 228
Rosin varnishes,
  cracking of, 229
  with resinates and tung-oil, 228
Rottenstone,
  and oil polishing, 279
  and water polishing, 278
  use of,
    in polishing, 278
    in polishing-oils, 280
Roughness of surface of wood, 17
Rough rubbing with lump pumice-stone, 274
Rubbing,
  coats of varnish, 272
  carvings and rounded surfaces, 275
  drying after rubbing, 276
  enameled surfaces, 199
  felts for, 276
  lacquer-films, with pumice-stone, 336
    with sandpaper, 335
  oil-rubbing not used between coats, 277
  oils for, 277
  oil stains off, 54
  procedure for, 275
  rag, for shellacking lathe work, 189
  to dull finish, 274
  to satin-finish, 276
  with
    lump pumice-stone, 274
    machines, 277
    oil and sandpaper, 274
    pads or blacks, 275
    pumice-stone powder and water, 274
    water-proof sandpaper, 274
Rubbing-enamels, 198
Rubbing-varnishes,
  contain but little drier, 261
  placed over spar-varnishes, 261
  short-oil type, 261
Russet, mixing the color, 81
Russet paint, 385

S

Sage, 81
Salt dyes, 125
Sandarac,
  formerly used in lacquers, 169
  hardness of the gum, 169
  in early varnishes, 214
  in lacquers, 287
  origin of gum, 168
  solubility of, 165
  solvents for, 169
  used with shellac in varnishes, 169
  varnishes, 164
Sanding before painting, 386
Sandpaper,
  blocks, 30
  double-coated, 27
  for wet sanding, 27
  grit from crushed rock, 27
  made from strong paper, 27
  manufacture, 26
  manufacture of, 27
  scratches on finished surface, highly magnified, 160
  sizes, 30
  types of, 32
  used by automobile finishers, 32
  use of, 30
  Wetordry, use of, 160
Sandpapered surfaces, dusting of, 35
Sandpapering,
  a filled surface, 159
  a priming coat of paint, 203
  between lacquer-films, 334
  cell walls of wood illustrated, 34
  curved surfaces, 30
  faults of amateurs, 31
  over,
    defect on surfaces, 20
    lacquer finishes, 329
    old finishes, 208
    rubbing-varnish, 274
    shellacked surfaces, 179
  preparing old surfaces for lacquering, 326
  procedure in, 31-32
  rounding off arrises, 160
  shellacked surfaces, 182
  size of grit to use, 31
  to produce smooth surfaces, 35
  undercoats, 205
    before filling, 151
Sandpapering—*Cont.*
  varnish undercoats, 270
  veneered surfaces, 35
  very fine paper required, 160
  with wet sandpaper, 32
Sanitation improved by paints, 341
Sap-wood streaks and water-stains, 45
Satin finish,
  enamels, 200
  on varnishes, 254
  rubbing with oil, 276
Saturation of a color, 79
Scarlet lake, 364
Scrapers,
  curved, 23
  sharpening of, 21
  unsatisfactory on soft woods, 23
  used in hands, 20
Scraping,
  of wood, 22
  surface of wood, 29
Scratching by incorrect sanding, 30
Secondary colors, 80
Second coat of paint, formula for, 378
Seed-lac, 172
Sepia, 96, 372
Setting time of varnish, 266
Shade of colors, 78
Shellac, 164
  as an enamel undercoat, 203
  as transparent filler, 139
  best spirit-varnish, 169
  bleached or white, 174
  brushes, cleaning of, 185
    selection and care of, 183
    use of, 184
  characteristics of the gum, 169
  colored to match stains, 75
  finishes, destroyed by heat or soap, 181
  grades of, 170
  grinding japans, 244
  made from lac-gum, 169
  mixture for lathe polishing, 189
  mixtures for French polishing, 186
  sticks for repairing dents, 25
  substitutes, 183
  under filler, 152
  wash, over volatile oil-stains, 56
  wash coat, over stains, 152

Shellac—*Cont.*
  washes, purpose and composition of, 179
Shellac-gum,
  adulteration of, 172
  bleached,
    deteriorates with age, 177
    solubility of, 173
  bleaching of, 176
  cooling in sheets, 172
  deposited on trees, 170
  difficult to cut in alcohol, 174
  garnet-lac and button-lac, 172
  heating in long bags, 172
  in grinding japans, 258
  in lacquers, 287, 293
  melting of seed-lac, 172
  not easily soluble in lacquer-solvents, 323
  produced by insects, 170
  purifying of, 173
  two crops annually, 171
  where found, 170
Shellacked surfaces,
  drying and sanding of, 179
  rubbing of, 182
  rubbing with pumice-stone, 183
  sandpapering of, 182
  use of steel wool on, 182
Shellacking,
  flowing with a brush, 184
  in damp weather, 180
  on lathe work, 189
  over knots, 202
  rag used on lathe work, 189
Shellac-varnish,
  absorption of water by alcohol in, 174
  adulteration of, 176
  alcohol in, 173
  amount of gum in, 175
  and dampness, 271
    outdoor exposure, 177
  application of, 178
  as a filler, 178
  as a finishing material, 181
  bleaching with oxalic acid, 175
  "blushing" of, 180
  characteristics of, 174
  cloudy effect of in damp weather, 180
  darkening of, 175
  dust trouble with, 175
Shellac-varnish—*Cont.*
  easy spreading of, 179
  effects of metal cans and dust on, 175
  effects of water in, 174
  evaporation of alcohol from, 175
  formulae, 174
  good and bad qualities of, 180
  keeps well in glass, 175
  nonpermeable, 177
  not good outdoors, 181
  orange, 174
    and white, 176
    keeping of, 176
    use of, 178
  preparation of, 173
  satisfactory for lacquer under-coats, 323
  shellac-wax in, 181
  spreading of, 178
  thinning of, 175
  under spar-varnish, 177, 178
  used
    by pattern-makers, 178
    diluted, 178
  uses of, 177
  with
    camphor-gum, 178
    glycerine and Venice turpentine, 180
Shellac-wax, 173
  in shellac-varnish, 181, 337
Shingle stain of creosote-oil, 55
Short-oil
  in white enamels, 263
  polishing varnishes, 261
  varnishes, 262
Siccatives or driers, 240
Sienna,
  burnt, 364
  raw, 364
    ferric oxide permanent color, 367
Sierra Leone gum, 222
Silex,
  from crushed rock, 143
  in fillers, 142
  in paints, 358
  in wood-fillers, 358
Silica (or silex), 358
  from crushed quartz, 143
Silver white, in fillers, 142
Sizing-varnishes, 262

Slate paint, 385
Softeners, purpose of in lacquers, 303
Soft gum varnishes, 165
Solubility of soft gums, 165
Solid-solution theory of dyeing, 94
Solvent, meaning of term in lacquer industry, 295
Solvent oils, used in oil-stains, 135
Solvents,
  and diluents classified by boiling-points, 296
  for lacquers, in combinations, 297
  for nitrocellulose, 310
  for nitrocellulose and resins, 294
  for oil-soluble dyes, 129
  for spirit-varnishes, 164
  for varnishes, 218
    information about, 248
Soy-bean oil, 231
Spar-varnishes, 263
  oils in, 263
Spiriting-off, shellac on lathe work, 190
Spirit-soluble dyes used in varnishes, 133
Spirit-stains,
  and applying stains, 59
  and volatile-oil stains mixed, 60
  characteristics of, 59
  drying and penetration of, 59
  evaporation and fire-risk of, 60
  lifting of with shellac, or filler coat, 59
  made from basic dyes, 60
  method of application of, 60
  soluble in water or alcohol usually, 122
  tendency to fade, 60
  use of, 59
  volatile, 135
Spirit-varnishes, 164
  classification of, 164
  defined, 164
  list of, 164
  resins used in, 164
Spirit-varnish lacquers, 287
Spirit-varnish resins, 164
  soluble in alcohol, 165
    turpentine or benzol, 165
Spirit-varnish solvents, 164
Sponging and resanding, 33
Spontaneous combustion,
  from oil-pads, 280
  from oil-soaked rags, 392
Spray-gun, use of, 331
Spraying-lacquer, formula for, 312
Spraying lacquer with an air-gun, 330
Spraying outfits,
  for lacquering, 330
  school made, 331
Spraying-varnishes, 263
Staining,
  speed in, 62
  use of brushes and wiping, 61
  wood with a brush, superficial, 132
Staining of wood,
  and color harmony, 37
  for pleasing tones, 37
  for preservation, 37
  reasons for, 37
Stains,
  application of, 61
  chemical, 64
  oil, 50
  pigment, 50
  preservative, 50
  solvents in penetrating type of, 50
  under lacquers, 325
  volatile oil, 50
  water, popularity of, 40
Steel wool,
  sizes of, 33
  uniformness of grit, 33
  use of, 33
Stick-lac, composition of, 173
Stone paint, 385
Straining paint, 377
Sublimed white lead, 351
Substantive dyes, 125
Sulphur dyes, 128
Surface of wood, preparation of, 16
Surface preparation,
  for chemical staining, 68
  for enamels, 202
Sycamore, finishing of, 393
Synthetic dyes, classification of, 109
Synthetic resins in lacquers, 293

T

Tack-rags, 269
Tannic acid,
  reaction of with ammonia, 66
  use and characteristics of, 67

Tannic acid—*Cont.*
  used in wood-stains, 39
Tannin dye, 101
Tan paint, 385
Temperature checks in lacquer films, 306
Terra verte, 370
Tertiary colors, 81
Texaco spirits, 240
  use in varnishes, 249
Textile dyes, ancient, 97
Thiazole colors, 116
Thinning and working properties of varnishes, 265
Thinner,
  added to hot varnishes, 239
  for flat paints, 204
  for enamels, 196
  for fillers, 153
  for paints, 345
  in lacquers, 306
  purpose of, 240
Thinning varnishes, 264
Tint, of color, 78
Titanium oxide, as a paint pigment, 355
Titanox,
  and titanium oxide, 354
  as a paint pigment, 354
  mixed with zinc white, 354
  obscuration of, 354
Toluene,
  as a lacquer thinner, 307
  boiling point of, 107
  from light tar-oil, 111
  not a solvent for nitrocellulose, 307
  or toluol, use in lacquers, 311
Tone, 79
Transparent filler, use of, 139
Triphenylmethane dyes, 112
Turkey-red, 100
Tung-oil, 234
  amount of used in varnishes, 248
  drying properties of, 235
  flatting effect of, 254
  information about, 248
  in rosin and ester-gum varnishes, 235
  in spar-varnishes, 263
  properties of in varnishes, 235
  treatment of, 234
  viscosity of, 236
Turmeric, 101
Tuscan red, 363
Turpentine, 236
  absorbs oxygen, 237
  added freely to varnishes, 266
  addition of
    to melted gums, 264
    varnish, 270
  amount used in varnishes, 239
  as a paint thinner, 375
  boiling point of, 239
  flatting effects of, 375
  functions of in varnishes, 248
  imparts brushing qualities, 238
  in enamels, 196
  in oil-soluble stains, 129
  in paint, 345
  is a slow-drying volatile-oil, 238
  is chemically active, 238
  is an oxygen carrier, 238
  kinds of, 237
  solid matter in, 238
  specific gravity of, 238
  substitutes, 239
    list of, 240
  thinner for flat paints under enamels, 204
  uses of, 239
Tyrian purple, 96
  synthetic, 104

U

Ultramarine blue,
  and related blues, 368
  not good with white lead, 391
  not mixed with chrome yellow or white lead, 368
  permanent, 368
  with zinc white, 369
Ultra-violet rays decompose clear lacquers, 313
Umber,
  as a drier, 243
  burnt, 372-373
  raw, 372
Undercoat,
  flat enamel paint, 381
  flat paint, with lithophone, 353
Undercoats,
  for lacquers, 321
  of shellac, 203

V

Value, of color, 79
Vandyke brown,
  imitation of, 373
  used as a walnut stain, 373
Varnish,
  addition of thinners to hot mixtures of, 239, 240
  application of, 270
    in ancient Egypt, 213
  architectural, 251
  automobile, 251
  baking, 251
  black, gums used in, 253
  book-binders' contains sandarac, 169
  brushes,
    cleaning, 283
    preparation of, 268
    use of, 270
  classification of, 216
  coach, 252
  coats, sanding of between, 273
  color of, 266
  containing China wood-oil, 222
  cooking effects on, 266
  covering power of, 272
  darkened by long cooking, 267
  drying of,
    by evaporation and oxidation, 231, 236, 240
    on damp days, 269
  drying-oils in, 231
  dyes used in, 133
  early composition of unknown, 213
  early formulas contained sandarac, 214
  East India soft gum in, 254
  effects of heat on, 252
  elasticity of, 266
  ester-gum in enamel-varnishes, 253
  exterior, 252
  films,
    drying of, 273
    rubbing of, 272
    staying in place of, 266
    thickness of, 266
    wrinkling of, 272
  finishing, 252
  flat,
    mixing, 255
    or mat, 254
Varnish—*Cont.*
  flatting with beeswax, 255
  flowing, 256
  flowing qualities of, 236, 265
  for floors, 256
  for furniture, 256
  for gear and chassis, 256
  for preservation and beauty, 215
  for undercoats, 271
  for use in enamels, 252
  from soft gums, 165
  gloss-oil, 257
  grinding, 257
  hard-oil, 258
  heat-proof, 258
  in floor-paints, 390
  in paints, 244
  insulating, 259
  interior, 258
  japans, purpose of, 217
  kinds that will rub, 273
  leveling properties of, 266
  long-oil,
    in enamels, 194
    is elastic, 259
  luster of, 266, 267
  making,
    directed by scientists, 219
    little changed till recently, 214
    secrets of, 218
    temperatures of, 220
  manufacture, improvements in, 185
  marine, 259
  medium-oil for baking-enamels, 253
  middle ages type with drying-oils, 215
  mixing, 259
  oil,
    composition of, 218
    contains drying-oils, 216
    made from amber, 212
    resins in, 218, 221
    use of amber in ancient, 214
  oil or oleoresinous, history of varnish making, 212
  on early paintings, 214
    origin of name, 212
  over enamels, 217
  piano, 260
  polishing, 260
  purpose of, 215

- Varnish—*Cont.*
  - removal of gloss on, 271
  - rosin,
    - and tung-oil, 228
    - cracking of, 229
  - rubbing, 261
    - methods of, 273
    - with oil, 274
  - sandpapering of, 274
  - setting time of, 266
  - short-oil, 262
    - in enamels, 200
  - sizing, 262
  - solvents, 218
  - spar, 263
  - spirit, 164
  - spraying, 263
  - tack-rags, 269
  - Theophilus Presbyter's formula for, 214
  - thickness of coats of, 272
  - thinned freely with turpentine, 266
  - thinners, 236
    - information about, 248
    - mixing temperatures of, 240
  - thinning of, 264
    - by users, 270
  - told of by Pliny, 214
  - types of, 251
    - in enamels, 204
  - under- and over-cooked, 221
  - used,
    - as a binder in enamels, 195
    - by ancient Egyptians, 213
  - vehicles in, 247
  - viscosity of, 264
  - warming of, 270
  - wipers on containers, 270
  - working and thinning properties of, 265
- Varnish-chimney,
  - photograph of, 219
  - purpose of, 220
- Varnished paintings of ancient Egypt, 339
- Varnish-gums,
  - fossil, 221
  - hard, melted with oils, 216
  - in lacquers, 288
- Varnishing,
  - brushes for, 268
  - conditions for, 265
- Varnishing—*Cont.*
  - dusting before, 268
  - number of coats used, 272
  - on lathe work, 190
  - over
    - old finishes, 269
    - sandpapered undercoats, 271
  - panels, method of, 270
  - preparations for, 267
- Varnish ingredients changed by heat, 221
- Varnish-kettle, 219-220
  - copper and aluminum, 232
- Varnish-lacquer,
  - dries slowly, 288
  - possible new finish, 314
- Varnish-oils,
  - linseed, 232
  - with lead driers, 233
  - with manganese drier, 233
- Varnish-removers,
  - cleaning after use of, 269
  - formulas for, 283
  - may burn skin of hands, 282
- Varnish-resin
  - and oil mixing, 220
  - cooking of, 220
  - functions of, 245-246
  - information about, 245
  - Manila gums, 225
  - or gums, 245
  - rosin, 226
  - solubility of in hot oils, 220
  - use in lacquers, 291, 309
- Varnish-removers, 282
- Varnolene, 218, 240
  - used in varnishes, 249
- Vat dyes, 128
- Vegetable dyes, 96
  - aloes extract, 99
  - camwood bark, 102
  - cutch, or catechu, 100
  - Flavin, 103
  - fustic, 101
  - gallnuts, 100
  - madder extract, 99
  - mordant, 127
  - patent bark, 103
  - quercitron, 102
- Vehicles (see drying-oils), 247
  - for bronze and aluminum paints, 375
  - for paints, functions of, 343

Vehicles—*Cont.*
  functions of in varnishes, 247
  in fillers, 143
Venetian red, 361
  composition of, 362
Vermilion, 363
Veronese green, 370
Violet paint, 385
Viridian, 371
Viscosity
  of drying-oils, 236
  of varnishes, 264
Volatile oils, list of, 236
Volatile-oil solvents or thinners, 236
Volatile oil-stains, 55
  bleeding into varnish coats, 57
  coloring-matter in, 56
  lifting of, 57
  oils in, 56
  permanency of, 56
  wiping of, 56

W

Wall (interior) paints, formulas for, 380
Walnut,
  American, fillers and stain for, 148
  antique, filler for, 148
  black, finishing of, 393
  Circassian, 148
  paint, 386
  wood, filled surface of, highly magnified, 159
Warm colors, 79
Warning, lacquering with an air-gun increases fire risk, 333
Waste-can, for safety from fires, 280
Water-color paints, 345
Water-proof,
  enamels, 199
  shellac, 337
  varnishes, 264
    not for furniture, 268
Water-soluble colors, solubility of, 133
Water-staining,
  and loose glue joints, 43
  beginning and ending of, 48
  care of brushes with, 47
  helpful hints on, 46
  on end-grain, 46
Water-stains,
  acid, under lacquers, 325
  advantages of, 40
  and sap streaks, 45
  application, procedure of, 45
  applied evenly, 48
  brush application of is difficult, 45
  care in application of, 46-47
  change of color with, 41
  cheap per gallon, 42
  clear effects with, 42
  dark shades with, 41
  dipping with, 41
  disadvantages of, 43
  dry quickly, 43
  hot application of, 42
  on veneers, 48
  penetrate thru one coat linseed-oil, 43
  penetration of, 41
  permanency of, 42
  popularity of, 41
  preliminary preparation for, 41
  solubility of, 41
  use of brushes with, 41
  variety of colors with, 41
  will darken a filled surface, 41
Wax-finishes, removal of, 269
Wax, removal of, 208
Wet weather painting, 386
White lead,
  and whiting in putty, 389
  buckles, 347
  corroding, chemistry of, 349
  darkened by sulphur in ultramarine blue, 391
  formula for, 347
  grinding of, 350
  making by Carter process, 350
  manufacture of, 347
  (8% oil) oil paste, 378
  paint mixtures, 378-379
  paints over red-lead priming, 382
  paste, 352
  poisonous, 391
  properties and uses of, 352
  sublimed, 351
  with zinc-white, 379
Wiping stains, 61
Woad, 98
Wood,
  absorptive, with water-stains, 53

Wood—*Cont.*
  advantages of dryness of, 15
  cellular structure of, 34
  close-grained, stain for, 53
  effects of,
    dampness in, 15
    moisture on kiln-dried stock, 15
  fibers, arrangement of, 30
  list of showing type of filler required, 161
  porosity of, under a microscope, 162
  preparation of surface of, 16
  proper moisture content of, 15
  surface,
    examination of with microscope, 16
    planing by hand, 18
  turpentine, 237
  value of moisture content tests in, 15
  various, finishing of, 393
Wood-alcohol shellac-varnish, 173
Wood-filler, 137
  classes or types of, 138
  containers for, 145
  in pores of chestnut wood, 138
  liquid, 138
    for non-porous wood, 138
    ingredients in, 140-141
    thinner for, 141
  paste, 138, 141
    body-materials in, 141, 143
    colored pigments in, 145
    composition of, 143
    covering power of, 144
    early kinds of, 141
    formula for, 144
    keeping qualities of, 144
  mixing of, 144
  plug up open pores, 137
  purpose of, 137
  special, under lacquers, 323
  transparent, 138
    use of, 139
  type of required, 137
    on various woods, Table V, 160
Wood-lacquers, 291
  formula for, 312
  have heavy body, 313
Wood-staining, definition of, 38
Wood-stains,
  acid and alkaline, 39
  and colors, 78
  and water-staining, 37
  classification of, 38
  from basic dyes, 125
  from coal-tar, 92
  from vegetable and mineral materials, 40
  water, formerly not permanent, 40
  water-soluble powders and chemicals used in, 39
  without mordants, 125
Working properties of varnishes, 265
Wrinkling of coats of varnish, 272

X

Xanthene colors, 113
Xylene,
  a lacquer thinner, 307
  boiling point of, 107
  from light tar-oil, 111
  or Xylol, use in lacquers, 311

Y

Yellow ocher
  in priming paints, 387
  origin and formula for, 365
Yellow pigments, list of, 365
Yellow, other,
  aurora yellow, 367-368
  cadmium yellow, 367-368
  Naples yellow, 367-368

Z

Zinc and white lead paint, 379
Zinc lead, 352
Zinc oxide,
  amount of oil in paste, 353
  and white lead mixtures, 352
  as a paint pigment, 352
  less opaque than white lead, 353
Zinc-white, 352
  discolored by linseed-oil, 194
  paste, 376

Heterick Memorial Library
Ohio Northern University

DUE	RETURNED	DUE	RETURNED
1.		13.	
2.		14.	
3.		15.	
4.		16.	
5.		17.	
6.		18.	
7.		19.	
8.		20.	
9.		21.	
10.		22.	
11.		23.	
12.		24.	

WITHDRAWN FROM
OHIO NORTHERN
UNIVERSITY LIBRARY

HETERICK MEMORIAL LIBRARY
698.3 N54c 1930
Newell, Adnah Clift/Coloring, finishing
onuu
3 5111 00119 7098

.3N54C1930 | 21024 | NEWELL/COLORING FINISHING | 01
CALL NUMBER | ACCES. NO. | MAIN ENTRY

DO NOT REMOVE FROM THE BOOK POCKET
A FEE WILL BE CHARGED FOR LOSS OF OR
DAMAGE TO THIS CARD

MASTER

HETERICK MEMORIAL LIBRARY
ADA, OHIO 45810

OGLC

Heterick Memorial Library
Ohio Northern University
Ada, Ohio 45810

2102